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Cephalopod beak identification and biomass estimation techniques: tools for dietary studies of southern Australian finfishes.

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Front cover illustration beaks of (top to bottom): *Sepia hedleyi*, *S. irvingi* and *S. plangon* (upper beak on left, lower beak on right). Photos: Wen-Sung Chung

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Cephalopod beak identification and biomass estimation techniques: tools for dietary studies of southern Australian finfishes

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1 Non-technical summary

Lu, C. C., and Ickeringill, R. 2003. Cephalopod beak identification and biomass estimation techniques: tools for dietary studies of southern Australian finfishes. *Museum Victoria Science Reports* 6: 1–65.

Need for this research. Squid, octopus and cuttlefish (cephalopods) are known to be an important food source for many marine animals including whales, porpoise, seals, seabirds, tuna, sharks and swordfish. The hard beaks (chitinous mandibles) of these preys are frequently encountered in predator stomachs. Cephalopod beaks can be used to identify the prey species and to calculate prey size and biomass consumed. Such hard parts from fishes (i.e. otoliths and vertebrae) have long been used for these purposes. Cephalopod species in the northern hemisphere have also had such tools available, but until now little information has been available on this aspect of the cephalopod fauna of our region.

Results and conclusions. A key of cephalopod beaks of 75 southern Australian species is available to identify samples taken from predators in this region for the first time, along with the formulae required to calculate prey size and biomass.

Production of this key required the analysis of 1596 specimens, involving detailed measurements of various parts of the whole animal (mantle length, animal weight) and the beaks. Statistical analysis of the data then allowed the description of the relationship between beak measurements and the size and weight of animals, providing formulae to back calculate prey size and biomass.

A table provides details of the species examined, classified to order and family, with information on the size and weight range of whole animals. Most complete beaks can be easily identified to the order level and a key is provided for this. Further keys are provided to allow identification to genus/species level within each of the four orders. Detailed descriptions of beaks are provided for each species, supplemented by further tables providing ranges, ratios and means of various beak characters.

Further work. Collection and analysis of further cephalopod beak material would allow the formulae developed here to be further refined. A similar project with a scope that included the tropical cephalopod fauna of Australia would be valuable to workers in northern Australia and nearby regions.

2 Background

The hard parts of cephalopods, primarily the chitinous mandibles, or beaks, are frequently encountered in the stomachs of a wide range of predators. Through the identification of beaks, cephalopods are known to be an important food source for whales (Gaskin and Cawthorn, 1967; Clarke and MacLeod, 1976; Clarke et al., 1976; Clarke, 1977; Clarke and Kristensen, 1980; Clarke and MacLeod, 1982; Seagars and Henderson, 1985; Kubodera and Miyazaki, 1993; Sekiguchi et al., 1996), porpoise (Wilke and Nicholson, 1958; Perrin et al., 1973; Kuramochi et al., 1993), seals (Austin and Wilki, 1950; Laws, 1960; Clarke and Trillmich, 1980), seabirds (Ashmole and Ashmole, 1967; Imber, 1978; Clarke and Prince, 1981), tuna (Pinkas et al., 1971; Perrin et al., 1973; Matthews et al., 1977), sharks (Stevens, 1973; Clarke and Stevens, 1974; Tricas, 1979; Dunning et al., 1993) and swordfish (Toll and Hess, 1981; Bello, 1991; Guerra et al., 1993; Hernandez-Garcia, 1995).

Attributes of beak morphology provide the opportunity to both identify prey and back-calculate prey size and the scale of biomass consumed. Such hard parts from fishes (i.e. otoliths and vertebrae), have long been used for these purposes, with atlases of otolith identification having been produced for many fish families (e.g. Smale et al., 1995) By contrast, although extensive work has been carried out on cephalopods from northern hemisphere waters (Mangold and Fioroni, 1966; Clarke, 1962, 1986; Iverson and Pinkas, 1971; Hotta, 1973; Wolff, 1982, 1984), little information is available for the identification of cephalopods from the southern hemisphere.

3 Need

There is currently no guide to beak identification and prey size back-calculation for cephalopods of the Southern Hemisphere, despite their high profile in the diets of many valuable and heavily exploited commercial fishes. At present, all expertise in beak identification is centred in a few researchers, creating enormous backlogs of material to be identified, resulting in lengthy delays in provision of data requested for fisheries and other marine research projects.

Over the past decade, there have been repeated approaches made to the primary researcher to provide both identifications of cephalopod prey and indications of prey size, distributions and biomass. These requests have originated from fisheries as well as seabird, pinniped and cetacean researchers.

4 Objectives

To produce a diagnostic illustrated key for identification of cephalopod beaks in the diets of marine vertebrates from southern Australian waters.

To analyse relationships between beak morphometrics and whole animal attributes, in order to develop back-calculation formulae for estimation of prey size and biomass.

5 Methods

5.1 Study material

The beaks from 1596 positively identified, whole specimens from 75 species of southern Australian cephalopod were examined (Table 1). Before removing the beak, dorsal mantle length (ML) and weight of the animal were recorded. For the majority of specimens, mantle length was measured with callipers accurate to 0.1 mm. and weights of the preserved (WtP) and where possible fresh (WtF) animal were measured using an electronic balance accurate to 0.5g. For the largest specimens, accuracy is reduced through the use of rulers and Japanese scales for measurements. Beaks were either removed fresh or chemically dissected from the buccal mass using trypsin (enzyme) or concentrated KOH. While using concentrated KOH is a quick process, careful monitoring is essential as severe distortion can occur, especially in smaller beaks, and for this reason it is not recommended. Specimens and beaks are stored in 70% ethanol. All specimens are housed in the Invertebrate Collection, Museum Victoria.

Beak dimensions were measured, accurate to 0.1mm, using digital callipers or an ocular micrometer. Measurements used for all species are upper and lower hood length (UHL, LHL), upper and lower rostral tip to wing base (URW, LRW), upper and lower crest length (UCL, LCL) and lower baseline length (LBL) as defined by Clarke (1962, 1986) (Fig. 1). Lower rostral tip to lateral wall free corner length (LRF) is also measured for all species. Additionally, for teuthid species only, upper and lower rostrum length (URL, LRL), and upper and lower jaw width (UJW, LJW) were measured. Where possible all measurements were made for each specimen. These dimensions were converted to ratios for direct comparison between species.

5.2 Data analysis

Linear regressions to describe the relationship between beak dimensions and mantle length and body weight were carried out for each individual species. The general regression equation used is; $y = c + mx$, where y is the dependant variable, being dorsal mantle length of the animal (ML), or natural log transformed weight of either the fresh (ln WtF), or preserved (ln WtP) animal, c is the constant (or Y-intercept), m is the slope of the regression line and x is the beak dimension (or independent variable). The natural log of beak dimensions are used for estimating the natural logged weight. Beak dimensions used for equations for all species are upper and lower hood length, upper and lower crest length and lower rostral tip to free corner length. For teuthid species, equations using upper and lower rostral length were also performed. These dimensions were chosen because of their ease of measurement, to allow comparison with previous work and across species, and to provide choice to the scientist depending on beak condition. Regression equations are only given where the slope of the regression line has been determined as significantly different from zero using a students t-test. Resulting r^2 values and number of cases (n) are also given and should be considered when using these equations for back-calculation. All statistics were carried out using SYSTAT.

5.3 Species descriptions

Descriptive characters used for the upper beak follow those of Clarke (1962) and Wolff (1982), with one additional character, posterior hood/wing margin, identified (Fig. 2A). Lower beak characters follow those of Clarke (1986) (Fig. 2B). Orientation of the lower beak for all descriptions and illustrations is opposite to that in which it would be found in life.

Table1. Details of southern Australian cephalopod species examined

The old order Sepioidea is now recognized as consisting of two distinct orders, Sepiida and Sepiolida. The old usage is retained here for ease discussion below.

Order	Family	Species	Number of specimens	ML range (mm.)	Preserved Wt range (g.)
Sepioidea	Spirulidae	*Spirula spirula*	8	37.5 - 43.3	5.2 - 7.8
	Sepiidae	*Sepia apama*	33	14.4 - 430.0	0.5 - 9554.0
		Sepia braggi	21	18.2 - 79.0	0.8 - 23.9
		Sepia chirotrema	18	74.3 - 157.0	44.6 - 309.8
		Sepia cultrata	30	44.0 - 101.7	10.7 - 93.8
		Sepia hedleyi	33	38.3 - 116.6	7.0 - 128.3
		Sepia irvingi	9	74.1 - 164.0	49.7 - 454.1
		Sepia mestus	7	25.4 - 99.6	2.6 - 109.1
		Sepia novaehollandiae	27	26.3 - 152.6	2.8 - 359.2
		Sepia plangon	30	37.6 - 93.1	4.7 - 70.8
		Sepia rozella	30	35.2 - 119.7	5.4 - 175.8
	Sepiadariidae	*Sepiadarium austrinum*	12	11.5 - 26.6	1.3 - 4.6
		Sepioloidea lineolata	20	14.0 - 30.0	1.6 - 10.9
	Sepiolidae	*Rossia australis*	30	21.0 - 50.0	4.6 - 50.2
		Heteroteuthis serventyi	25	11.2 - 26.5	0.7 - 5.9
		Iridoteuthis sp.	16	7.0 - 19.3	0.4 - 3.2
		Sepiolina nipponensis	11	16.9 - 24.0	1.7 - 4.0
		Euprymna tasmanica	17	16.5 - 31.0	1.9 - 11.4
	Idiosepiidae	*Idiosepius notoides*	1	N/A	N/A
Teuthida	Loliginidae	*Sepioteuthis australis*	37	49.0 - 383.0	14.1 - 511.0
		Uroteuthis (Photololigo) noctiluca	32	29.9 - 85.4	1.8 - 27.3
	Lycoteuthidae	*Lycoteuthis lorigera*	49	35.6 - 177.1	3.3 - 227.4
	Enoploteuthidae	*Enoploteuthis galaxias*	33	29.3 - 120.2	2.5 - 57.8
		Enoploteuthis sp.	14	72.0 - 126.0	12.1 - 49.8
		Abraliopsis gilchristi	28	24.0 - 47.5	0.7 - 5.5
		Abraliopsis tui	12	20.0 - 32.5	0.6 - 2.6
		Pyroteuthis margaritifera	28	17.0 - 39.0	0.3 - 5.1
		Pterygioteuthis gemmata	19	15.5 - 33.0	0.1 - 1.3
		Pterygioteuthis giardi	4	15.0 - 20.7	0.1 - 0.5
	Ancistrocheiriidae	*Ancistrocheirus lesueuri*	6	28.1 - 190.0	4.0 - 502.2
	Octopoteuthidae	*Octopoteuthis* sp.	18	36.0 - 340.0	4.3 - 2297.0
		Taningia danae	1	1260.0	N/A
	Onychoteuthidae	*Onychoteuthis banksii*	11	23.2 - 86.0	0.4 - 13.4
		Ancistroteuthis sp.	21	22.2 - 116.5	0.9 - 30.0
		Moroteuthis ingens	14	304.0 - 560.0	640.0 - 6500.0
		Moroteuthis robsoni	8	352.0 - 688.0	694.0 - 5332.0
	Lepidoteuthidae	*Lepidoteuthis grimaldii*	2	755.0 - 844.0	N/A
	Pholidoteuthidae	*Pholidoteuthis boschmai*	8	45.3 - 564.0	2.8 - 4908.0
	Architeuthidae	*Architeuthis* sp.	5	424.0 - 2400.0	145000 - 220000
	Histioteuthidae	*Histioteuthis atlantica*	26	16.2 - 188.0	1.3 - 598.4
		Histioteuthis bonnelli corpuscula	21	12.0 - 74.0	0.6 - 194.5
		Histioteuthis eltaninae	6	12.5 - 65.0	0.3 - 80.0
		Histioteuthis macrohista	8	15.1 - 47.2	2.7 - 65.3
		Histioteuthis miranda	31	23.5 - 237.0	4.5 - 1800.0
		Histioteuthis reversa	12	27.0 - 64.0	3.4 - 54.2
	Bathyteuthidae	*Bathyteuthis abyssicola*	12	27.8 - 59.1	2.1 - 13.5
	Ctenopterygidae	*Ctenopteryx siculus*	13	27.0 - 68.0	1.4 - 17.3
	Brachioteuthidae	*Brachioteuthis* cf. *riisei*	25	34.0 - 97.0	0.9 - 18.4
	Ommastrephidae	*Todaropsis eblanae*	29	20.8 - 168.0	1.5 - 212.5
		Todarodes filippovae	102	47.0 - 555.0	43.9 - 3352.0
		Nototodarus gouldi	93	74.0 - 370.0	14.0 - 1340.0
		Ommastrephes bartrami	29	65.8 - 405.0	5.8 - 2065.7
		Eucleoteuthis luminosa	25	31.0 - 174.0	1.1 - 108.1
		Ornithoteuthis volatilis	40	34.0 - 202.0	1.9 - 175.6
	Mastigoteuthidae	*Mastigoteuthis cordiformis*	6	220.0 - 915.0	405.7 - 6650.0
	Cranchiidae	*Cranchia scabra*	18	46.2 - 130.0	2.3 - 39.7
		Liocranchia reinhardti	27	62.0 - 138.0	1.5 - 24.2
		Megalocranchia abyssicola	9	43.0 - 450.0	0.7 - 337.0
		Sandalops melancholicus	9	31.0 - 86.0	0.9 - 12.9
		Teuthowenia pellucida	42	29.5 - 170.0	0.7 - 52.6

Table 1 (cont.)

Octopoda	Grimpoteuthidae	*Grimpoteuthis* sp.	3	70.1 - 280.0	N/A
	Opisthoteuthidae	*Opisthoteuthis persephone*	34	8.8 - 54.0	13.5 - 695.5
		Opisthoteuthis pluto	7	27.7 - 44.3	134.2 - 542.2
	Octopodidae	*Octopus berrima*	37	19.9 - 84.0	5.8 - 433.8
		Octopus bunurong	13	11.6 - 57.6	1.0 - 63.0
		Octopus kaurna	28	11.2 - 60.0	2.0 - 57.8
		Octopus maorum	17	20.5 - 340.0	14.2 - 10500.0
		Octopus pallidus	43	18.0 - 130.0	3.2 - 251.5
		Octopus superciliosus	10	12.0 - 25.0	1.3 - 10.0
		Octopus warringa	11	13.4 - 25.8	1.2 - 5.1
		Hapalochlaena maculosa	31	13.1 - 31.3	1.9 - 40.3
		Eledone palari	12	17.9 - 57.8	6.5 - 67.2
	Ocythoidae	*Ocythoe turberculata*	16	14.0 - 48.2	2.0 - 56.9
	Argonautidae	*Argonauta nodosa*	12	44.2 - 132.4	35.4 - 309.1
Vampyromorpha	Vampyroteuthidae	*Vampyroteuthis infernalis*	11	25.3 - 63.0	4.1 - 114.6
TOTAL			1596	7.0 - 2400.0	0.1 - 220000

Illustrations are given to show the major identifying features of each species. All upper beaks are illustrated from the side view with lower beaks illustrated from oblique and/or side views. Additionally, ventral views of some beaks are given. Beaks of sufficient size were digitally image captured using a Zeiss SV-11 Stereo microscope with a CCD attachment. For smaller beaks, a camera lucida was used for line drawings.

6 Results and Discussion

Most complete upper and lower beaks can be easily identified to the order level. Keys for this first level of identification are provided below. Further identification within the specified group can then be carried out using the keys and beak descriptions provided under each order heading.

Key for the identification of upper beaks of southern Australian cephalopod orders

1 Jaw angle distinct, posterior hood/wing margin convex 2
– Jaw angle absent or indistinct, posterior hood/wing margin may be concave, straight, or convex 3
2 Jaw angle obtuse with large false angle, well defined double edge on inner rostrum, no cartilage on shoulder, no indentation of posterior margin of lateral wall .... Vampyromorpha, some Histioteuthidae
– Does not have all features listed above .... Most Teuthoidea, some Sepioidea
3 Hood short, UHL/UCL ~ 0.4, posterior hood/wing margin concave or straight .... Incirrata (benthic), Octopodidae
– Hood not short, UHL/UCL 0.5-0.8, posterior hood/wing margin convex.. 4
4 No indentation of posterior lateral wall margin, lateral wall not deep .... Cirrata Finned Octopoda, i.e., Grimpoteuthidae, Opisthoteuthidae
– Large indentation of posterior lateral wall margin, lateral wall deep... 5
5 Large colourless margin, cutting edge may be jagged, crest wide ....Incirrata (pelagic Octopoda, i.e., Ocythoidae, Argonautidae)
– Small colourless margin, cutting edge smooth.................... ....Sepiidae, some Sepiolidae

Key for the identification of lower beaks of southern Australian cephalopod orders

1 Hood and wings very broad, LHL/LCL ~0.9, wing fold very high forming cutting edge and hiding distinct jaw angle in profile...Vampyromorpha
– Hood and wings not as broad as above, LHL/LCL <0.8, more often ~0.5-0.6. 2
2 Wing fold, angle point, step and clear strip absent. Jaw angle absent, or rarely obtuse. If lateral wall fold present runs to position anterior to free corner. Often midline indentation of posterior darkened lateral wall, no indentation to sides of crest .... Octopoda
– One or more of wing fold, angle point, step or clear strip or jaw angle present. If lateral wall fold or ridge present runs towards free corner or posterior lateral wall margin. May be indentation of posterior darkened lateral wall to sides of crest, usually no midline indentation 3
3 Jaw angle absent, or rarely obtuse. Generally no lateral wall fold or ridge, indentation of posterior darkened lateral wall to sides of crest, step, clear strip, or hood notch. Wings long, LRW/LCL ≥ 1.0. Beak has trapezoid shape overall, LCL/LBL ~ 0.8 ~ LCL/LRF.................. Sepioidea
– Jaw angle distinct. May be lateral wall fold or ridge, indentation of posterior darkened lateral wall to sides of crest step, clear strip or hood notch. Generally, LCL/LBL ≠ 0.8 ≠ LCL/LRF..Teuthoidea

6.1 ORDER SEPIOIDEA

Key for identification of southern Australian Sepioidea upper beaks

1 Tiny beak, cutting edge serrated, lateral walls colourless..... ....*Idiosepius notoides*
– Cutting edge not serrated, lateral walls usually pigmented... 2
2 Broad rostral edge with pitted surface, no pigment stripes on inner crest. Chiton thick and dark in larger beaks. UHL often exceeding 8mm. ....*Sepia*
– Rostral surface not pitted, inner rostrum smooth or with double edge, may have pigment stripes on inner crest. UHL not exceeding 8mm...3

3 Inner rostrum smooth from shoulder to tip, no pigment stripes on anterior inner crest .... *Spirula spirula*
– Inner rostrum with double edge, may be pigment stripes on anterior inner crest 4
4 Deep indentation of posterior margin of lateral wall 5
– Shallow indentation of posterior margin of lateral wall 7
5 No pigment stripes on anterior inner crest...*Rossia australis*
– Two pigment stripes on anterior inner crest 6
6 Large colourless margin of over half lateral wall, even in mature specimens .... *Euprymna tasmanica*
– Small colourless margin, especially in mature specimens.... .... *Sepiolina nipponensis, Iridoteuthis* sp.
7 No pigment stripes on anterior inner crest...... Sepiadariidae
– Two pigment stripes on anterior inner crest .... *Heteroteuthis serventyi*

Key for identification of southern Australian Sepioidea lower beaks

1 Tiny beak, cutting edge serrated, wings colourless in all specimens .... *Idiosepius notoides*
– Cutting edge not serrated, wings pigmented in mature specimens 2
2 Broad edged wing fold, not forming groove to sides of rostral edge .... *Sepia, Spirula spirula*
– Wing fold forming groove to sides of rostral edge 3
3 Low lateral wall ridge present .... *Heteroteuthis serventyi*
– No trace of lateral wall ridge 4
4 Hood diamond shaped from above ....*Iridoteuthis* sp
– Hood not diamond shape from above 5
5 Free corner of lateral wall not pigmented............................ .... *Euprymna tasmanica*
– Pigmentation extends to lateral wall free corner 6
6 Broad darkened wing area opposite position of jaw angle in squid .... Sepiadariidae
– Darkened wing area opposite position of jaw angle in squids narrows........*Rossia australis, Sepiolina nipponensis*

Southern Australian Sepioidea beak descriptions including equations for the back-calculation of length and mass

ORDER SEPIOIDEA

Upper beak: Rostrum curved, pointed tip. If present, jaw angle not recessed. Hood without clear strip often seen in ommastrephids, not short, generally UHL/UCL>0.5. Posterior hood/wing margin convex. Wing extends to, or nearly to, base anterior lateral wall margin. Anterior shoulder edge not distinctly rounded. Crest slightly curved, unthickened.
Lower beak: Hood with shallow, or more often, no notch. No clear strip or step between anterior margin of lateral wall and wing. Crest generally shorter than distance between rostrum and free corner, LCL/LRF ~0.8, and baseline, LCL/LBL ~0.8.

SPIRULIDAE

Spirula spirula (Fig 3)
Upper beak: Darkening process unknown, lateral walls fully darkened at UHL 2.9mm. Inner rostrum smooth. Jaw angle close to 90° or absent, cutting edge may be broken or irregular. Broad hood curved in profile, low on crest compared to other sepioids, 0.5-0.6 UCL. Posterior hood/wing margin weakly convex. Lateral walls not touching in dissected specimens, shallow or no indentation of posterior margin of lateral wall.
Lower beak: Darkening process unknown, wings fully darkened at LHL 1.1mm. Rostral edge curved, may be irregular. Wings with short, low wing fold opposite area of jaw angle, wings widely spread. Crest unthickened, may be infold to either side. Jaw angle variable, may be hidden in profile. Shoulder tooth may be present. Angle point absent. Broad, darkened band in lateral wall which is slightly thickened in cross section running towards free corner. No indentation of posterior darkened lateral wall to sides of crest.

No significant relationship was found between UHL and mantle length or total weight of preserved specimens, though mantle length can be estimated using the regression for UCL given in Appendix 3. Neither mantle length or total weight of preserved specimens can be estimated from the lower beak based on calculations from these specimens using LHL, LCL or LRL.

Clarke (1986) examined the lower beaks of 20 specimens of *S. spirula* and found consistency between beaks as well as a significant relationship between LRL against wet weight and mantle length. Lower beaks of *S. spirula* described by Clarke show some different characteristics to those described here. For example, Clarke found *S. spirula* to have a roof-shaped, unthickened lateral wall fold running to the posterior edge. None of the specimens examined in this study had this feature.

Though only eight specimens were examined here, combined with the variation shown between these beaks and those of Clarke (1986), and as no sexual dimorphism is evident, this may indicate the presence of another species or subspecies in this family.

SEPIIDAE

Due to the similarities of beaks from all Sepia species examined, beak descriptions and calculations are best given at the generic level.

Sepia (Figs 4-13)
Chitin becomes stiff in large specimens and is tougher than that found in most teuthids, ocotpods and other sepioids. Excluding S. braggi, one to three darkened bands were often observed in upper and/or lower beaks, easily viewed by holding the specimen up to light. Darkened bands may be thicker than lateral wall to either side or occasionally, thickened forming a low, narrow ridge. It is less common for bands in the lower beak to form a ridge.

In upper beaks bands are curved almost reaching the posterior lateral wall margin at or below the indentation, most distinct in *S. chirotrema* and *S. hedleyi*. In lower beaks, the bands are less curved running towards the lateral wall free corner. The bands become broader and less distinct with growth. No pattern for the presence or absence of this characteristic was discernible.

Equations for estimating mass from all *Sepia* spp. beaks from southern Australian waters are given below the upper and lower beak descriptions and it is recommended that these be used as beaks within this genus are not easily distinguished. Species specific calculations are given in Appendices 3 and 4, but should only be used where the beak can be positively identified.
Upper beak: Lateral wall darkening by spread from crest obvious in all except *S. chirotrema* where the smallest specimen examined was fully darkened. The size at which upper beaks become fully darkened is useful for distinguishing *S. apama* and *S. braggi* from other *Sepia* species (Table 2).

Table 2. Size of upper *Sepia* beaks at incomplete and full pigmentation

Species	UHL (mm) when pigmentation spreading from crest	UHL (mm) when lateral wall may be fully darkened
S. apama	2.9 – 20.8	31.0
S. braggi	2.2 – 2.4	2.6
S. chirotrema		8.4
S. cultrata	4.4 - 7.4	5.2
S. hedleyi	5.0 – 8.1	8.9
S. irvingi	8.9 – 12.8	17.2
S. mestus	4.1 – 10.7	14.6
S. novaehollandiae	4.4 – 6.0	5.2
S. plangon	4.2 – 10.5	9.2
S. rozella	4.9 – 11.5	10.1

Rostral tip often worn to a blunt point. Broad rostral edge with pitted inner surface. Hood curved, long, UHL ~0.7 UCL. No pigment stripes on inner surface of crest. Jaw angle absent in all, though may appear slightly acute in some *S. braggi*. Smooth cutting edge. Lateral walls often touching in dissected specimen. Deep indentation of posterior margin of lateral wall. Of the beaks examined, *S. apama* is the only species to exceed UHL 25mm.

Calculated regressions for all *Sepia* examined of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 13.83 + 6.66 UHL (r^2=0.95)

ln WtP = -2.16 + 2.68 lnUHL (r^2=0.91)

Lower beak: Darkening process unknown, wings of smallest specimens examined for each species darkened. Rostral tip blunt, pinched forming shallow groove in hood extending to posterior margin on either side. Hood high on crest. Wings long with low, broad fold, not forming a groove to sides of rostral edge. Darkened part of wing only slightly narrows at area opposite position equivalent to jaw angle in squid. Crest curved, unthickened in cross section taken immediately posterior to hood margin. Cutting edge curved, no jaw angle. Shoulder tooth absent, angle point absent. No lateral wall fold or ridge. Free corners often touching in dissected specimen. No indentation of posterior darkened lateral wall to sides of crest.

In most cases it is not possible to identify the 10 species of Sepia examined here using only the upper and/or lower beaks. Both the upper and lower beaks exhibit the same features across species and size ranges also overlap, S. apama being the only species to exceed 8.5mmLHL. Proportional comparisons between species are also very similar overlapping in range (Table 3).

SEPIADARIIDAE (Figs 14, 15)

The darkening process is unknown, though two lower beaks of Sepioloidea lineolata (0.9, 1.1mm LHL) exhibited a step pattern of darkening down the wings. The chitin of S. austrinum is very pale on the lateral walls and wings in comparison to S. lineolata.

Upper beak: Inner rostral surface with double edge extending anteriorly of shoulder, not as well developed in Sepiadarium. austrinum. Jaw angle variable. No pigment stripes on inner crest. Lateral walls spread parallel, shallow indentation of posterior margin of lateral wall.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

S. austrinum ML = 3.73 + 5.52 UHL (r^2=0.53, n=12)

lnWtP = -1.23 + 2.09 lnUHL (r^2=0.87, n=12)

S. lineolata ML = 2.60 + 5.49 UHL (r^2=0.76, n=20)

lnWtP = -1.69 + 2.57 lnUHL (r^2=0.91, n=20)

Lower beak: Rostral edge curved with blunt tip. Jaw angle variable. Wings with low wing fold forming groove to sides of rostral edge. Darkened part of wing broad opposite area of jaw angle in squid. Crest unthickened. Angle point absent, shoulder tooth absent. No lateral wall fold or ridge, no thickening of lateral wall, normal spread of free corners. No indentation of posterior darkened lateral wall to sides of crest, though blunt midline indentation present.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

S. austrinum ML = 0.96 + 14.17 LHL (r^2=0.55, n=12)

lnWtP = 0.33 + 2.29 lnLHL (r^2=0.79, n=12)

S. lineolata ML = 7.86 + 10.02 LHL (r^2=0.73, n=20)

lnWtP = 0.90 + 1.94 lnLHL (r^2=0.88, n=20)

SEPIOLIDAE

Species examined from this family show great variability with relatively few common characteristics. The upper beak has a jaw angle which is obtuse to 90°, with an anterior shoulder edge which may be irregular. The lower beak has a jaw angle which is obtuse or absent and usually hidden in profile. Darkened area of wing narrows opposite jaw angle, though not as obvious in E. tasmanica. Crest slightly curved, unthickened.

Rossia australis (Fig 16)

Upper beak: Lateral walls colourless at UHL 3.8mm., pigmented at UHL 5.2mm. Inner rostrum with double edge, groove broad and deep at inside shoulder narrowing anteriorly, may be worn. No pigment stripes on inner crest. Deep indentation of posterior margin of lateral wall.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -4.06 + 7.58 UHL (r^2=0.62, n=28)

lnWtP = -2.60 + 3.27 lnUHL (r^2=0.80, n=28)

Lower beak: Wings colourless at LHL 1.7mm., pigmented from LHL 1.8mm. Rostrum with blunt tip. Low, broad wing fold forming slight groove to sides of rostral edge. Rounded shoulder tooth, worn down in larger specimens. Angle point absent. No lateral wall fold or ridge. Blunt midline indentation of posterior darkened lateral wall, no indentation to sides of crest.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 11.01 + 11.82 LHL (r^2=0.43, n=30)

lnWtP = 1.25 + 2.12 lnLHL (r^2=0.54, n=30)

Heteroteuthis serventyi (Fig 17)

Upper beak: Darkening process unknown, lateral wall fully darkened at UHL 2.2mm. Inner rostrum with double edge, broad, shallow groove at inside shoulder narrowing anteriorly. Anterior inner crest with 2 pigment stripes. Shallow indentation of posterior margin of lateral wall.

Table 3. ***Sepia*** **upper and lower beak ratios, ranges and means**

	UPPER BEAK			LOWER BEAK			
Species	URW/UHL, *x*	URW/UCL, *x*	UHL/UCL, *x*	LRW/LHL, *x*	LHL/LCL, *x*	LCL/LRF, *x*	LCL/LBL, *x*
S. apama	0.42-0.69, 0.53	0.33-0.54, 0.40	0.70-0.83, 0.77	1.96-3.33, 2.39	0.36-0.53, 0.46	0.76-0.91, 0.85	0.70-1.04, 0.87
S. braggi	0.44-0.68, 0.55	0.27-0.43, 0.35	0.59-0.69, 0.63	1.96-3.50, 2.72	0.33-0.52, 0.42	0.72-0.88, 0.80	0.70-0.95, 0.81
S. chirotrema	0.44-0.62, 0.55	0.32-0.41, 0.37	0.61-0.72, 0.67	2.01-3.20, 2.56	0.39-0.54, 0.44	0.75-0.89, 0.81	0.66-0.92, 0.81
S. cultrata	0.46-0.71, 0.59	0.33-0.43, 0.38	0.60-0.72, 0.65	2.17-3.99, 2.65	0.38-0.54, 0.46	0.75-0.89, 0.83	0.66-0.86, 0.74
S. hedleyi	0.46-0.62, 0.53	0.32-0.46, 0.37	0.65-0.76, 0.71	2.00-3.13, 2.46	0.40-0.55, 0.48	0.78-0.92, 0.83	0.69-0.94, 0.82
S. irvingi	0.48-0.58, 0.53	0.36-0.44, 0.40	0.68-0.82, 0.75	2.30-3.13, 2.70	0.38-0.51, 0.44	0.75-0.87, 0.80	0.73-0.90, 0.82
S. mestus	0.38-0.54, 0.45	0.28-0.38, 0.34	0.69-0.83, 0.76	2.15-3.24, 2.63	0.37-0.49, 0.44	0.79-0.91, 0.84	0.60-0.84, 0.72
S. novaehollandiae	0.46-0.65, 0.55	0.30-0.47, 0.41	0.65-0.84, 0.73	2.09-3.28, 2.67	0.38-0.52, 0.45	0.75-0.93, 0.83	0.69-0.94, 0.80
S. plangon	0.44-0.61, 0.52	0.30-0.48, 0.37	0.65-0.83, 0.73	1.86-3.18, 2.50	0.40-0.59, 0.47	0.78-0.97, 0.86	0.62-0.91, 0.76
S. rozella	0.38-0.60, 0.51	0.28-0.47, 0.37	0.67-0.90, 0.74	2.07-3.73, 2.86	0.38-0.54, 0.45	0.74-0.93, 0.80	0.62-0.83, 0.74

Calculated regressions for all *Sepia* examined of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 18.09 + 16.50 LHL (r^2=0.95,)

ln WtP = 0.70 + 2.51 lnLHL (r^2=0.92)

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -12.72 + 10.34 UHL (r^2=0.82, n=24)

lnWtP = -3.75 + 4.21 lnUHL (r^2=0.88, n=24)

Lower beak: Stage when darkened wing patch connected by an isthmus at LHL 1.0mm, wings fully darkened at LHL 1.3mm. Distinct wing fold, highest opposite jaw angle, forming deep groove to sides of rostral edge. Shoulder tooth rounded or absent. Angle point short, narrow, becoming indistinct in larger specimens. Broad, low lateral wall ridge, running towards free corner, not reaching posterior margin. Broad midline indentation of posterior lateral wall, deep indentation of darkened lateral wall to sides of crest.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -3.73 + 16.66 LHL (r^2=0.65, n=25)

lnWtP = 0.01 + 3.12 lnLHL (r^2=0.71, n=25)

Iridoteuthis sp. (Fig 18)

Upper beak: Darkening process unknown, lateral walls fully darkened at UHL 1.4mm. Inner rostrum with double edge, groove broad and deep at inside shoulder narrowing anteriorly. May be 2 short pigment stripes on anterior inner crest. Deep indentation of posterior margin of lateral wall.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -1.67 + 6.58 UHL (r^2=0.51, n=16)

lnWtP = -1.85 + 2.81 lnUHL (r^2=0.83, n=16)

Lower beak: Wings colourless at LHL 0.7mm., fully darkened at LHL 1.1mm. Hood diamond shaped from above. Distinct wing fold, highest opposite jaw angle, forming groove to sides of rostral edge. Shoulder tooth small or absent. Angle point broad and short. No lateral wall fold or ridge, may be infold either side of crest. Blunt midline indentation of posterior darkened lateral wall, no indentation to sides of crest.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -2.14 + 12.81 LHL (r^2=0.58, n=16)

lnWtP = -0.02 + 2.64 lnLHL (r^2=0.83, n=16)

Sepiolina nipponensis (Fig 19)

Upper beak: Darkening process unknown, lateral walls pigmented at UHL 2.7mm.. Inner rostrum with double edge, groove broad and deep at inside shoulder narrowing anteriorly. Two pigment stripes on anterior inner crest. Deep indentation of posterior margin of lateral wall.

No relationship was found between UHL and mantle length in these specimens. Calculated regression of UHL in mm. against total weight of preserved specimens (WtP) in grams is:

lnWtP = -1.94 + 2.73 lnUHL (r^2=0.67, n=11)

Lower beak: Darkening process unknown, wings pigmented at LHL 1.3mm. Short, low wing fold forming broad groove to sides of rostral edge. Shoulder tooth absent. Angle point blunt, short and indistinct, only visible in smallest specimens (LHL<1.4mm.). No lateral wall fold or ridge. Shallow, blunt midline indentation of posterior lateral wall, no indentation to sides of crest.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 4.61 + 10.74 LHL (r^2=0.45, n=10)

lnWtP = 0.57 + 1.56 lnLHL (r^2=0.51, n=10)

Euprymna tasmanica (Fig 20)

Upper beak: Lateral walls darken by spread, large colourless margin even in mature specimens. Inner rostrum with double edge, groove broad at inside shoulder narrowing anteriorly, may be worn so that double edge is at inside shoulder only. Anterior inner crest with 2 pigment stripes. Deep indentation of posterior margin of lateral wall.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -4.67 + 6.96 UHL (r^2=0.78, n=17)

lnWtP = -3.44 + 3.62 lnUHL (r^2=0.88, n=17)

Lower beak: Darkening process unknown, large colourless

margin even in mature specimens. Rostral tip slightly pinched. Low, broad wing fold with gentle slope to rostral edge. Shoulder tooth absent, angle point absent. No lateral wall fold or ridge, no indentation of posterior darkened lateral wall.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 0.85 + 14.39 LHL (r^2=0.75, n=16)
lnWtP = 0.35 + 2.84 lnLHL (r^2=0.85, n=16)

IDIOSEPIIDAE

Idiosepius notoides (Fig 21)
Only one specimen was examined, the chitin of which was soft and flexible. Beaks of this species are easily recognisable by the serrated cutting edge, apparent in both upper and lower beaks. Upper and lower beak wings and lateral walls remain colourless even in mature specimens. Additionally, the upper beak has a smooth inner rostrum, a short hood which is low on the crest, widely spread lateral walls which have a shallow indentation of the posterior wall margin. The lower beak has a diamond-shaped, long hood covering most of the crest. The wings are widely spread without a wing fold and there is no lateral wall fold or ridge.

6.2 ORDER TEUTHIDA

Key for identification of southern Australian Teuthida upper beaks

1 Inner rostral surface smooth from inside shoulder to tip, no false angle 2
– Inner rostral surface not smooth from inside shoulder to tip, may be false angle.. 10
2 Indentation of posterior lateral wall margin 3
– No indentation of posterior lateral wall margin 8
3 Very large sized beak, lateral walls colourless at URL6.90mm., rostrum short ~ ¼ hood length .... *Architeuthis* sp.
– Small to medium sized beak, lateral walls fully darkened by URL6.90mm., rostrum may be short............................ 4
4 Wing extends ½-2/3 length of anterior lateral wall............ 5
– Wings extends to, or nearly to, base of anterior lateral wall margin 7
5 Medium sized beak, crest almost straight, hood clear strip extends posterior to jaw angle except in largest specimens . ... *Todaropsis eblane, Ornithoteuthis volatilis*
– Small sized beak, crest moderately curved, no hood clear strip extending posterior to jaw angle 6
6 Whole rostrum and shoulder darkly pigmented .... *Ctenopteryx siculus*
– Rostral edges only darkly pigmented................................ .... *Uroteuthis (Photololigo) noctiluca*
7 Small sized beak, fully darkened at URL0.57mm, small colourless margin, pigmentation brown/black .... *Pterygioteuthis gemmata*
– Medium to large sized beak, large colourless margin even in mature specimens, pigmentation yellow/brown.............. .... *Sepioteuthis australis, Cranchia scabra,* .... *Liocranchia reinhardti*
8 Rostrum narrow, URL/UJW= 1.2-1.7, lateral walls colourless at URL6.2mm .... *Megalocranchia abyssicola*
– Rostrum wide, URL/UJW= 0.9-1.3, lateral walls fully darkened at URL 0.78mm... 9
9 Two pigment stripes may be visible on inner crest, posterior hood/wing margin diagonal, hood short, UHL/UCL ~0.6.............................. *Bathyteuthis abyssicola*
– No pigment stripes on inner crest, posterior hood/wing margin weakly convex, hood not short, UHL/UCL ~0.7...... .... *Pyroteuthis margaritifera, Pterygioteuthis giardi*
10 Jaw angle acute .... *Todarodes filippovae,* .... *Nototodarus gouldi, Ommastrephes bartrami,* .... *Eucleoteuthis luminosa*
– Jaw angle obtuse to 90° 11
11 Inner rostral surface with several ridges ..... *Taningia danae,* .... *Lepidoteuthis grimaldii*
– Inner rostral surface with double edge (two ridges), may be at inside shoulder only 12
12 Two pigment stripes on inner crest surface ..*Abraliopsis* sp. .... *Sandolops melancholicus*
– No pigment stripes on inner crest surface........................ 13
13 Posterior hood/wing margin diagonal....... *Octopoteuthis* sp.
– Posterior hood/wing margin distinctly convex 14
14 Shoulder edge broken ....*Histioteuthis* sp., ... *Teuthowenia pellucida*
– Smooth, distinctly rounded shoulder edge....................... 15
15 Wing extends halfway to base anterior margin of lateral wall .... *Ancistrocheirus lesueuri,* ....*Moroteuthis* sp., *Pholidoteuthis boschmai,* ....*Mastigoteuthis cordiformis*
– Wing extends 2/3 to just above base anterior margin of lateral wall .... *Lycoteuthis lorigera,Enoploteuthis* sp., ... *Onychoteuthis banksii, Ancistroteuthis* sp.

Key for identification of southern Australian Teuthida lower beaks

1 Fold or ridge in lateral wall when sectioned immediately behind posterior hood margin (Fig. 2B) 2
– No fold or ridge in lateral wall when sectioned immediately behind posterior hood margin 21
2 Lateral wall fold..3
– Lateral wall ridge..12
3 Lateral wall fold reaches posterior margin above halfway between crest and free corner .... *Todaropsis eblane,* .... *Todarodes filippovae, Nototodarus gouldi,* .... *Ommastresphes bartrami*
– Lateral wall fold reaches posterior margin halfway or below halfway between crest and free corner.....................4
4 Lateral wall fold reaches posterior margin halfway between crest and free corner..5
– Lateral wall fold reaches posterior margin below halfway between crest and free corner 10
5 Crest thickened in cross section...6
– Crest not thickened in cross section..................................9
6 Deep, sharp hood notch, rostrum strongly curved, protrudes forward .... *Pholidoteuthis boschmai*
– Broad hood notch, rostrum not strongly curved or protruding forward..7
7 Step below jaw angle .... *Moroteuthis robsoni*
– No step below jaw angle..8
8 Jaw angle acute, clear strip present below jaw angle, shoulder tooth present......................*Eucleoteuthis luminosa*
– Jaw angle obtuse, no clear strip below jaw angle, shoulder tooth absent..............................*Megalocranchia abyssicola*
9 Clear strip below jaw angle, jaw angle acute .... *Ornithoteuthis volatilis*
– No clear strip below jaw angle, jaw angle obtuse to 90° ......

.... *Teuthowenia pellucida*
10 Large indentation of posterior darkened lateral wall to sides of crest .... *Lepidoteuthis grimaldi*, ... *Taningia danae, Octopoteuthis* sp.
– Small or no indentation of posterior darkened lateral wall to sides of crest 11
11 Rostrum longer than hood length, jaw angle obtuse, LCL/LBL ≤0.75 .... *Ancistrocheirus* sp
– Rostrum shorter than hood length, jaw angle acute to 90°, LCL/LBL ≥0.80 .... *Mastigoteuthis cordiformis*
12 Ridge broad, low thickening of lateral wall..................... 13
– Ridge a distinct knob or fin in cross section.................... 14
13 Small sized beak, fully darkened at LRL0.88mm., ridge not reaching posterior margin, crest not thickened in cross section .... *Pyroteuthis margaritifera*
– Medium sized beak, wings colourless at LRL2.40mm., upper margin of ridge reaches posterior wall margin halfway between crest and free corner, crest thickened in cross section .... *Lycoteuthis lorigera*
14 Ridge runs halfway between crest and free corner 15
– Ridge runs below halfway between crest and free corner 18
15 Crest short, LHL/LCL≥0.5 16
– Crest not short, LHL/LCL<0.5 17
16 Small sized beak, fully darkened at LRL 1.5mm .... *Abraliopsis* sp.
Medium sized beak, wings colourless at LRL2.0mm.......... .... *Enoploteuthis* sp.
17 Crest and ridge strongly curved, LCL/LRF>0.75................ .... *Moroteuthis ingens*
– Crest and ridge not strongly curved, LCL/LRF≤0.70.......... .... *Ancistroteuthis* sp.
18 Free corner drawn out, lower margin of lateral wall highly arched .... *Brachioteuthis riisei*
– Free corner not drawn out, lower margin of lateral wall not highly arched 19
19 Long step below jaw angle, darkened area of wing opposite jaw angle narrow, crest not thickened .... *Onychoteuthis banksii*
– No step below jaw angle, darkened area of wing opposite jaw angle broad, crest thicker than lateral wall to either side 20
20 Lateral wall ridge knob shaped in cross section ....*Histioteuthis atlantica, Histioteuthis eltaninae*, ... *Histioteuthis reversa*
– Lateral wall ridge fin shaped in cross section...................... ....*Histioteuthis b. corpuscula,Histioteuthis macrohista*, ... *Histioteuthis miranda*
21 Hood notch deep, crest thickened in cross section 22
– Hood notch shallow or absent, crest not thickened in cross section 23
22 Hood high on crest, hood notch sharp. Chitin very flexible. Very large beak, wings colourless at LRL 5.9mm .... *Architeuthis* sp.
– Hood normal on crest, hood notch blunt. Chitin not flexible. Medium to large beak, wings either with isolated spot or fully darkened at LRL 5.3mm ....*Todaropsis eblane*, ... *Todarodes filippovae, Nototodarus gouldi*, ... *Ommastresphes bartrami*
23 Pigmentation distinct, only rostral edge darkly pigmented .. .. *Uroteuthis (Photololigo) noctiluca*
– Whole rostrum darkly pigmented 24
24 Angle point present, clear strip may be present below jaw angle 25
– Angle point absent, no clear strip below jaw angle.......... 26
25 Clear strip below jaw angle, jaw angle acute, large shoulder tooth...... *Cranchia scabra, Liocranchia reinhardti*
– No clear strip below jaw angle, jaw angle close to 90°, no shoulder tooth.............................. *Sandolops melancholicus*
26 Hood short, LHL/LCL<0.50 .... *Sepioteuthis australis*
– Hood not short, LHL/LCL≥0.50 27
27 Very large indentation of darkened posterior lateral wall margin extending to posterior hood. If crest darkened, very narrow. .... *Bathyteuthis abyssicola*
– Small indentation of darkened posterior lateral wall to sides of crest, crest darkened for most of length 28
28 Small sized beak, wings fully darkened at LRL0.65mm., chitin brown/black .... *Pterygioteuthis* sp.
Medium sized beak, wings colourless at LRL0.69mm., spot conneeted to hood at LRL0.94mm., chitin yellow/brown.... .... *Ctenopteryx siculus*

Southern Australian Teuthida beak descriptions including equations for the back-calculation of length and mass

LOLIGINIDAE

Upper beak: Rostrum short, URL/UHL≤0.33, rostral edge curved. Inner rostrum surface smooth without pigment stripes. No clear strip in hood posterior to jaw angle. Posterior margin of hood/wing complex convex. Crest curved. Prominent indentation of posterior margin of lateral wall.
Lower beak: Rostrum wide, LRL/JW ~ 1, shorter than hood, LRL/LHL<1. Jaw angle obtuse, visible from side. Wings without wing fold, widely spread. Shoulder tooth absent. No step or clear strip between anterior margin of lateral wall and wing. Crest straight or only slightly curved, unthickened, without infold to sides. No lateral wall fold or ridge. No indentation of darkened posterior margin of lateral wall to sides of crest, free corners of lateral wall widely spread.

Sepioteuthis australis
Upper beak: Lateral walls colourless at URL 2.50mm., darken by spread, large colourless margin even in mature specimens. Rostrum and shoulder darkly pigmented, remainder pale yellow. Jaw angle acute, slightly recessed. Wing extends nearly to base anterior margin of lateral wall.

Calculated regressions of URL in mm. against mantle length (ML) in mm., fresh (ln WtF) and preserved (ln WtP) weight in grams are:

$ML = -21.30 + 63.83\ URL (r^2=0.89, n=37)$

$\ln WtF = 2.07 + 2.66 \ln URL\ (r^2=0.93, n=8)$

$\ln WtP = 2.39 + 2.47 \ln URL\ (r^2=0.86, n=11)$

Lower beak: Darkened spot extending over wing from below jaw angle from LRL 1.2mm. Rostrum, anterior hood and shoulder darkly pigmented, remainder pale yellow. Rostral edge curved, may be drawn out S shape. Hood with distinct broad notch. Broad wings. Angle point absent. Crest long, LCL/LHL>2.

Calculated regressions of URL in mm. against mantle length (ML) in mm., fresh (ln WtF) and preserved (ln WtP) weight in grams are:

$ML = -20.78 + 67.89\ LRL\ (r^2=0.93, n=36)$

$\ln WtF = 1.71 + 3.34 \ln LRL\ (r^2=0.91, n=7)$

$\ln WtP = 2.48 + 2.57 \ln LRL\ (r^2=0.93, n=11)$

Uroteuthis (Photololigo) noctiluca

The colouring of this species' beaks was not seen in any other species examined and is therefore a useful character for identification of fresh beaks or those which have been in the stomach for only a short time.

Upper beak: Rostral edge and tip only darkly pigmented, remainder of pigmentation pale yellow. Jaw angle close to 90°, varies from slightly obtuse to slightly acute. Wing extends 2/3 length of anterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 1.62 + 36.71 URL (r^2=0.80, n=31)

ln WtP = 1.07 + 2.69 ln URL (r^2=0.79, n=31)

Lower beak: Rostral edge only darkly pigmented, remainder of pigmentation pale yellow. Rostral edge straight with broad, blunt tip. Hood low on crest, without notch. Angle point short and indistinct, or absent.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 1.36 + 40.85 LRL (r^2=0.85, n=26)

ln WtP = 1.41 + 2.44 ln LRL (r^2=0.76, n=26)

LYCOTEUTHIDAE

Lycoteuthis lorigera

Chitin of mature specimens very dark and tough.

Upper beak: Darkening occurs by spread down lateral walls at URL 1.56-2.86mm., fully darkened at URL 3.00mm. Rostral double edge present on inner surface. Jaw angle obtuse to 90°, recessed behind rounded shoulder with small false angle. Posterior margin of hood/wing complex convex. Wing extends nearly to base anterior margin of lateral wall. Crest almost straight. No indentation of posterior margin lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -16.65 + 33.24 URL (r^2=0.90, n=48)

ln WtP = -0.17 + 3.22 ln URL (r^2=0.94, n=48)

Lower beak: Wings may be colourless at LRL 3.06mm., or darkened from LRL 2.56mm. Rostral edge curved, may have small hook, approximately same length as hood. Jaw angle obtuse to 90°, partly hidden from side by wing fold. Hood low on crest, with shallow notch. Wings with low thickened wing fold, darkened area opposite jaw angle narrow. Shoulder tooth small, rounded, or absent. Angle point sharp to lower darkened lateral wall margin, not visible in larger specimens. Step may be present between anterior margin lateral wall and wing. Crest curved, short, (LCL/LHL $\leq$ 2), just thicker than lateral wall to either side. Distinctive lateral wall ridge becoming broader posteriorly, running towards free corner, upper margin of ridge reaches posterior lateral wall margin halfway between crest and free corner. No indentation of posterior darkened lateral wall to sides of crest.

L. lorigera described here most closely resembles an unnamed species of *Lycoteuthis* shown in Duran (1964) and featured in Clarke (1986). Although many features of the lower beak show some variability such as the presence and shape of the shoulder tooth, presence of a rostral hook and step, the distinctive broadening ridge and narrow wing opposite the jaw angle were consistent in all specimens examined.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -13.04 + 34.56 LRL (r^2=0.92, n=45)

ln WtP = 0.32 + 3.00 ln LRL (r^2=0.95, n=45)

ENOPLOTEUTHIDAE

The genera *Pyroteuthis* and *Pterygioteuthis* are now placed in the family Pyroteuthidae; and the genus *Ancistrocheirus* is now placed in the family Ancistrocheiridae, however, for ease of discussion below, they are placed in the family Enoploteuthidae as prior to the changes made by Clarke (1988).

Upper beak: Rostrum curved. No clear strip on hood. Posterior margin of hood/wing complex convex.

Lower beak: Jaw angle usually obtuse to 90°. Hood low on crest, notch shallow or absent. Darkened part of wing opposite jaw angle narrow except in Pyroteuthis margaritifera. Small shoulder tooth or ridge may be present. Crest short, LCL/LHL<2. Very small or no indentation of posterior darkened lateral wall to sides of crest.

Enoploteuthis

Upper beak: Rostral double edge present on inner surface. Jaw angle obtuse, slightly recessed with small false angle anterior margin formed by lateral wall. Crest normal width, straight. Indentation of posterior margin of lateral wall.

Lower beak: Rostrum narrow, LRL/LJW > 1.5, approximately same length as hood, edge curved. Jaw angle most often obtuse and shoulder tooth absent, occasionally acute, recessed behind shoulder tooth. Jaw angle hidden from side by low, broad wing fold. Angle point short, blunt. Short step between anterior margin of lateral wall and wing, not as steep as in Onychoteuthidae. Crest curved, narrow, thickened. Well defined lateral wall ridge runs halfway between crest and free corner almost to posterior margin.

Enoploteuthis galaxias

Upper beak: Darkening by spread from crest at URL 2.16-2.73mm., fully darkened at 3.12mm. Wing extends nearly to base anterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -36.30 + 40.28 URL (r^2=0.89, n=33)

ln WtP = -0.54 + 3.35 ln URL (r^2=0.90, n=33)

Lower beak: Wings colourless in one specimen at LRL 2.77mm., but an isolated spot can appear on wings at LRL 2.28-3.11mm., fully darkened at LRL 3.5mm.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -13.59 + 28.29 LRL (r^2=0.93, n=33)

ln WtP = -0.03 + 2.57 ln LRL(r^2=0.93, n=33)

***Enoploteuthis* sp.**

Upper beak: Darkening process unknown, fully darkened at URL 4.34mm. Wing extends 2/3 length to base of anterior margin of lateral wall.

Calculated regressions of URL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -5.11 + 25.19 URL (r^2=0.72, n=14)

ln WtP = 0.52 + 2.06 ln URL (r^2=0.51, n=14)

Lower beak: Darkening stage with an isolated spot on wings at LRL 3.13-3.68mm., fully darkened at LRL 3.93mm.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -31.46 + 32.73 LRL (r^2=0.60, n=13)

ln WtP = -1.99 + 3.92 ln LRL(r^2=0.89, n=12)

Abraliopsis

Upper beak: Poorly formed double edge on inner rostral surface at inside shoulder. Jaw angle obtuse to 90°, small false angle, not recessed. Two pigment stripes on inner surface of anterior crest. Wing extends nearly to base of anterior margin of lateral wall. Crest normal width, slightly curved. Shallow indentation of posterior lateral wall margin.

The upper beaks of the two species examined here, *Abraliopsis gilchristi* and *Abraliopsis tui* share the same characteristics and no means to separate the species were found in this study. A. tui darkens by spread from URL 1.02 – 1.08mm, though one fully darkened specimen was examined at URL 1.00mm. All specimens examined of *A. gilchristi* were fully darkened, the smallest at URL 1.26mm.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

A. gilchristi ML = 4.05 + 24.18 URL (r^2=0.58, n=28)

ln WtP = 0.20 + 2.48 ln URL (r^2=0.67, n=28)

A. tui ML = 10.97 + 13.63 URL (r^2=0.65, n=12)

ln WtP = 0.02 + 1.73 ln URL (r^2=0.69, n=12)

Lower beak: Rostral edge curved, approximately same length as hood. Jaw angle hidden from side by wing fold. Angle point short, blunt. Crest curved, narrow, thickened. Lateral wall ridge running halfway between crest and lower lateral wall margin, not reaching posterior margin, ridge shorter and broader in A. tui.

Abraliopsis gilchristi

Lower beak: Darkening process unknown, fully darkened at LRL 1.47mm. Indistinct step may be present between anterior margin of relateral wall and wing.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimenstotal weight of preserved specimens (ln WtP) in grams are:

ML = 0.89 + 24.28 LRL (r^2=0.67, n=27)

ln WtP = -0.13 + 2.75 ln LRL(r^2=0.77, n=27)

Abraliopsis tui

Lower beak: Wings colourless at LRL 1.22mm., darkening process unknown but can be fully darkened at LRL 1.09mm. No step or clear strip between anterior margin lateral wall and wing.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 7.13 + 16.26 LRL (r^2=0.74, n=12)

ln WtP = -0.12 + 2.12 ln LRL(r^2=0.78, n=12)

Pyroteuthis

Pyroteuthis margaritifera

Upper beak: Lateral walls darkened by spread at URL 0.49-0.59mm., fully darkened at URL 0.68mm. Inner rostral surface smooth without pigment stripes. Jaw angle acute, recessed. Posterior margin hood/wing complex weakly convex. Wing extends nearly to base anterior margin of lateral wall. Crest curved, lateral walls widely spread. No indentation of posterior margin lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 5.67 + 27.55 URL (r^2=0.86, n=24)

ln WtP = 1.08 + 2.56 ln URL (r^2=0.91, n=24)

Lower beak: Wings colourless at LRL 0.59mm., isolated patch on wings at LRL 0.73-0.85mm., fully darkened at LRL 0.88mm. Rostral edge almost straight, shorter than hood length. Jaw angle not hidden from side by low wing fold. Wings broad, darkened area opposite jaw angle not distinctly narrow. Angle point short, broad and blunt. No step or clear strip between anterior margin of lateral wall and wing. Crest curved, wide, unthickened. Broad, low lateral wall ridge runs halfway between crest and free corner, not reaching posterior margin. Ridge indistinct from side view but clearly visible in cross section. Lateral walls widely spread.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 5.26 + 26.73 LRL (r^2=0.84, n=25)

ln WtP = 0.97 + 2.70 ln LRL (r^2=0.85, n=25)

Pterygioteuthis

Upper beak: Inner rostral surface smooth without pigment stripes. Jaw angle varies from obtuse to slightly acute, no false angle. Cutting edge usually broken, irregular in form. Wing extends to base anterior margin of lateral wall. Crest curved, lateral walls widely spread.

Lower beak: Rostrum wide, LRL/JW ~ 1, rostral edge almost straight, shorter than hood length. Jaw angle visible from side. Wings and lateral wall free corners widely spread. Angle point absent. No step or clear strip between anterior margin of lateral wall and wing. Crest almost straight, not thickened. No lateral wall fold or ridge, though thickened midsection visible in cross section, more marked in Pterygioteuthis gemmata.

Pterygioteuthis gemmata

Upper beak: Darkening process unknown, fully darkened at URL 0.57mm. Indentation of posterior margin lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams is:

ML = -1.23 + 42.36 URL (r^2=0.71, n=17)

ln WtP = 1.02 + 3.30 ln URL (r^2=0.77, n=17)

Lower beak: Darkening stage with an isolated spot on wings at LRL 0.64-0.69mm., can be fully darkened at LRL 0.65mm.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 4.54 + 35.33 LRL (r^2=0.70, n=19)

ln WtP = 0.89 + 2.61 ln LRL (r^2=0.69, n=19)

Pterygioteuthis giardi

Upper beak: Darkening process unknown, fully darkened at URL 0.61mm. Posterior margin hood/wing margin weakly convex. No indentation of posterior margin lateral wall. No significant relationship found between URL, or other upper beak dimensions, and mantle length or total weight of these preserved specimens .

Lower beak: Darkening process unknown, wings colourless at LRL 0.43mm., fully darkened at LRL 0.58mm. No significant relationship found between LRL, or other lower beak dimensions, and mantle length or total weight of theses preserved specimens.

ANCISTROCHEIRIIDAE

Ancistrocheirus lesueuri

Upper beak: Lateral walls darken by spread at URL 1.81-2.29mm., fully darkened at URL 3.10mm. Rostrum curved, rostral double edge present on posterior inner surface. Jaw angle obtuse with false angle, anterior margin of which is formed by lateral wall. Posterior margin hood/wing complex convex. Wing extends ½ length to base anterior margin of lateral wall. Crest straight. Shallow indentation of posterior margin of lateral wall.

Calculated regressions of UHL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:.

ML = -43.10 + 45.81 URL (r2=0.82, n=6)

ln WtP = -1.01 + 4.30 ln URL (r2=0.98, n=5)

Lower beak: Wings colourless at LRL 2.46mm., fully darkened at LRL 3.78mm., process unknown. Rostral edge curved or straight with small hook. Hood normal on crest, with shallow notch. Jaw angle obtuse, hidden from side by wing fold. Shoulder tooth pointed, absent in larger specimen. Angle point blunt, not extending to lower darkened margin of lateral wall. No step or clear strip between anterior margin lateral wall and wing. Crest curved, narrow, thickened. Lateral wall fold reaches posterior margin below halfway between crest and free corner. No indentation of posterior margin of lateral wall.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -32.50 + 33.39 LRL (r2=0.87, n=6)

ln WtP = -1.35 + 3.86 ln LRL (r2=0.96, n=5)

OCTOPOTEUTHIDAE

Upper beak: Jaw angle obtuse with small false angle. Posterior margin of hood/wing complex diagonal. Crest straight. No indentation of posterior margin of lateral wall.

Lower beak: As found by Clarke (1986), lower beaks of this family are very characteristic in shape and can only be confused with *Lepidoteuthis*. Rostral edge long, ~ 1.5 times length of hood, almost straight. Jaw angle 90°, not hidden from side by very low wing fold. Hood low on crest with deep, broad notch. Cartilage often on shoulder, no tooth. No step or clear strip between anterior margin of lateral wall and wing. Crest slightly curved, narrow, without infold to either side, crest short (LCL/LBL =0.52-0.67). Well defined lateral wall fold extending to posterior margin to below halfway between crest and free corner. Deep indentation of posterior darkened lateral wall to sides of crest, deepest in Octopoteuthis sp.

***Octopoteuthis* sp.**

Upper beak: Lateral walls colourless at URL 4.64 mm, darkening by spread from crest at URL 5.72-11.52mm., but some specimens fully darkened from URL 7.80mm. Rostrum narrow (URL/UJW ≥1.5), with double edge at inside shoulder on inner rostrum. Wing extends to base anterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm., fresh (ln WtF) and preserved (ln WtP) weights in grams are:

ML = -0.40 + 17.96 URL (r^2=0.96, n=18)

ln WtF = 0.74 + 2.30 ln URL (r^2=0.75, n=9)

ln WtP = -1.04 + 2.93 ln URL (r^2=0.97, n=13)

Lower beak: Wings colourless at LRL 5.67mm., darkening by spread down posterior part of wing observed in two specimens LRL 9.38, 11.47mm., may be fully darkened at LRL 7.72mm. Jaw angle not hidden from side by very low wing fold. Angle point narrow, sharp to dorsal margin of darkened lateral wall. Crest thickened.

Calculated regressions of URL in mm., against mantle length (ML) in mm., fresh specimens (ln WtF) and preserved specimens (ln WtP) weights in grams are:

ML = -1.51 + 18.55 LRL (r^2=0.95, n=18)

ln WtF = 0.23 + 2.54 ln LRL (r^2=0.81, n=9)

ln WtP = -0.85 + 2.84 ln LRL (r^2=0.97, n=13)

Taningia danae

Single specimen examined, darkening process unknown.

Upper beak: Several ridges on inner rostral surface. Wing extends halfway to base anterior margin of lateral wall. Cartilage on shoulder at URL 18.54mm.

Lower beak: Cartilage on shoulder which obscures jaw angle from side, LRL 20.30mm. Angle point indistinct in specimen examined. Crest not cut but appears thickened.

ONYCHOTEUTHIDAE

Upper beak: Rostrum curved. Jaw angle obtuse, jaw edge smooth. Posterior margin of hood/wing complex convex. Crest slightly curved. Indentation of posterior margin of lateral wall.

Lower beak: Rostral edge slightly curved, may have hook, approximately same length as hood in all but O. banksii. Hood short, generally less than half crest length. Jaw angle obtuse. Step between anterior margin of lateral wall and wing. Crest curved, narrow, without infold to either side, not thickened or only just thicker than the lateral wall to either side in mature specimens.

Onychoteuthis banksii

Upper beak: Darkening occurs by spread down lateral walls from crest at URL 1.67-2.54mm., one specimen fully darkened at 2.12mm. Double edge may be present on inner rostral surface with shallow groove between edges, or inner rostral surface may be smooth. Jaw angle slightly or not recessed, may have small false angle. Wing extends 2/3 length to base anterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -7.29 + 37.78 URL (r^2=0.77, n=11)

ln WtP = -0.23 + 3.09 ln URL (r^2=0.88, n=11)

Lower beak: Wings colourless at LRL 1.96mm., isolated patch on wing at LRL 2.02-2.36mm., fully darkened at LRL 2.21mm. Rostrum wide, LRL/JW ~1, longer than hood. Jaw angle visible from side. Hood with shallow, broad notch. Shoulder tooth absent. Angle point indistinct, to dorsal margin of darkened lateral wall. Long step between anterior margin of lateral wall and wing extending just past lower darkened margin of lateral wall. Crest unthickened. Lateral wall ridge (knob) running towards free corner, not reaching posterior margin. No indentation of posterior darkened lateral wall to sides of crest.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 2.31 + 32.75 LRL (r^2=0.86, n=10)

ln WtP = -0.04 + 2.80 ln LRL(r^2=0.94, n=10)

***Ancistroteuthis* sp.**

Upper beak: Lateral walls darken by spread from crest at URL 1.42-2.15mm., one specimen fully darkened at URL 1.90mm. Rostral double edge present on inner surface inside jaw angle. Jaw angle slightly, or not, recessed with very small false angle. Wing extends 2/3 length to base anterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -35.60 + 52.23 URL(r^2=0.92, n=20)

ln WtP = -0.28 + 3.21 ln URL (r^2=0.84, n=19)

Lower beak: Wings clear at LRL 1.72mm., isolated spot on wings at LRL 1.80-1.98mm., fully darkened at LRL 2.19mm. Jaw angle not hidden from side by very low wing fold. Hood with shallow, broad notch. Shoulder tooth absent. Angle point broad, indistinct, reaching lower darkened margin of lateral wall, not visible in large specimens. Step short. Crest unthickened. Lateral wall fold thickened anteriorly forming ridge (knob) reaching posterior margin halfway between crest and free corner. No indentation of posterior darkened lateral wall to sides of crest.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -42.06 + 63.03 LRL (r^2=0.88, n=19)

ln WtP = 0.09 + 3.23 ln LRL (r^2=0.83, n=18)

Moroteuthis

Upper beak: Wing extends halfway to base of lateral wall anterior margin.

Lower beak: Jaw angle hidden from side by wing fold

Moroteuthis ingens

Chitin very stiff and thick.

Upper beak: Darkening process unknown, fully darkened at URL 8.05mm. Inner rostrum surface with double edge extending anterior of jaw angle. Jaw angle with false angle, slightly recessed by rounded shoulder.

Calculated regressions of URL in mm. against mantle length (ML) in mm. and total weight of fresh specimens (ln WtF) in grams are:

ML = -472.59 + 99.91 URL (r^2=0.66, n=14)

ln WtF = -11.50 + 8.74 ln URL (r^2=0.84, n=12)

Lower beak: Darkening process unknown, fully darkened at LRL 9.76mm. Hood very low on crest with deep notch. Chitin adjacent to jaw angle and of posterior hood very thin and undarkened, may be absent causing large gap in rostral edge and anterior lateral wall. Darkened wing narrow opposite jaw angle. Step extends halfway to lower darkened margin of lateral wall. Crest strongly curved, unthickened. Lateral wall with distinctive curved ridge, reaching posterior margin. Slight rounded indentation of posterior darkened lateral wall to sides of crest.

No significant relationship found between LRL and mantle length or total weight of fresh specimens. This is probably due to the deterioration of the thin chitin around the jaw angle which is present in larger beaks even when removed from fresh specimens. Calculated regressions using LRF and LCL instead of LRL provide regressions with significant relationships to ML and ln WtP and can be found in Appendices 3-8.

Moroteuthis robsoni

Upper beak: Darkening process unknown, fully darkened at URL 6.10mm. Rostrum short ~ 0.26 length of hood, double edge on inner surface. Jaw angle may be slightly recessed.

Calculated regressions of URL in mm. against mantle length (ML) in mm. and total weight of fresh specimens in grams (ln WtF) are:

ML = -294.20 + 120.88 URL (r^2=0.74, n=8)

ln WtF = -3.59 + 5.78 ln URL (r^2=0.90, n=6)

Lower beak: Darkening process unknown, fully darkened at LRL 7.26mm. Hood low on crest, with broad notch which may be deep. Wings broad, widely spread, high thickened wing fold.

Angle point blunt, narrow, nearly reaching lower darkened lateral wall margin, not visible in larger specimens. Step almost to lower darkened margin of lateral wall. Crest thicker than lateral wall to either side. Lateral wall fold reaches posterior margin halfway between crest and free corner. Very small indentation of posterior darkened lateral wall to sides of crest.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of fresh specimens in grams (ln WtF) are:

ML = -652.91 + 151.03 LRL (r^2=0.87, n=8)

ln WtF = -9.15 + 8.07 ln LRL(r^2=0.94, n=6)

LEPIDOTEUTHIDAE

Lepidoteuthis grimaldii

Only 2 specimens examined for which weights had not been receorded. Darkening process unknown.

Upper beak: Rostrum curved, long, URL/UHL~ ½, narrow URL/UJW~1.9 inner rostrum with several low ridges. Jaw angle obtuse with small false angle formed by shoulder cartilage. Posterior hood margin blunt, squared. Posterior margin of hood/wing complex diagonal. Wing extends ½ length to base anterior margin of lateral wall. Crest almost straight. No indentation of posterior margin of lateral wall.

Calculated regression of URL in mm. against mantle length (ML) in mm. is:

ML = -801.18 + 88.12 URL (r^2=1.00, n=2)

Lower beak: Rostral edge nearly straight, long, 1.5 times length of hood and narrow LRL/JW > 1.5. Jaw angle acute, hidden from side by shoulder cartilage. Hood low on crest, with broad notch, shallow groove to either side of midline. Shoulder tooth absent. Angle point sharp, long. No step or clear strip between anterior margin of lateral wall and wing. Crest slightly curved, narrow, not cut but appears slightly thickened. Distinct lateral wall fold reaches posterior margin below halfway between crest and free corner. Deep indentation of posterior darkened lateral wall to either side of crest.

Calculated regression of LRL in mm. against mantle length (ML) in mm. is:

ML = -10.60 + 50.57 LRL (r^2=1.00, n=2)

PHOLIDOTEUTHIDAE

Pholidoteuthis boschmai

Upper beak: Darkening by spread down lateral walls from

crest at URL 1.18-2.61mm., fully darkened at URL 5.38mm. Rostral edge curved, double edge present on inner rostral surface. Jaw angle obtuse with small false angle. Posterior margin of hood/wing complex convex. Wing extends halfway to base of lateral wall anterior margin. Crest almost straight. Indentation of posterior margin of lateral wall.

Calculated regressions of URL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -11.54 + 48.38 URL (r^2=0.93, n=8)
ln WtF = -0.16 + 3.48 ln URL (r^2=0.75, n=4)
ln WtP = 0.71 + 2.68 ln URL (r^2=0.99, n=4)

Lower beak: Wings colourless at LRL 3.13mm., darkening probably begins with an isolated spot on wing which becomes joined to hood darkening at LRL 5.70mm. Rostrum becomes more curved and narrow (LRL/JW > 1.5) with growth. Jaw angle acute, recessed by shoulder tooth, visible from side except in largest specimen. Hood low on crest with deep, forked notch. Wings broad with no or low wing fold, darkened wing opposite jaw angle narrow. Shoulder tooth ridge-like in smaller specimens, absent in large specimens. Broad angle point to lower margin of darkened lateral wall, not visible in large specimens. No step or clear strip between anterior margin of lateral wall and wing. Crest slightly curved, narrow, thickened. Lateral wall fold reaches posterior margin halfway between crest and free corner. Slight indentation of posterior darkened lateral walls to sides of crest.

Calculated regressions of LRL in mm. against mantle length (ML) in mm., fresh (ln WtF) and preserved (ln WtP) weights in grams are:

ML = -4.32 + 38.41 LRL (r^2=1.00, n=8)
ln WtF = 0.01 + 3.11 ln LRL (r^2=0.97, n=4)
ln WtP = 0.70 + 2.27 ln LRL (r^2=1.00, n=4)

ARCHITEUTHIDAE

Architeuthis sp.

Chitin is soft and flexible

Upper beak: Lateral walls colourless at URL 6.90mm., fully darkened at URL 18.03mm. Rostrum short, URL ~ 1/4 UHL. Double edge with deep groove between edges of inner rostrum in one specimen, inner rostrum smooth in other four specimens. Jaw angle close to 90°, not recessed. Posterior margin of hood/wing complex strongly convex. Wing extends 2/3 length to base anterior margin of lateral wall. Crest straight. Indentation of posterior margin of lateral wall.

No significant relationship found between URL and mantle length or total weight of fresh specimens.

Lower beak: Wings colourless at LRL 5.87mm., fully darkened at LRL 18.03mm. Rostral edge straight, short, ~ 0.7 length of hood. Jaw angle acute, recessed, visible from side. Broad hood high on crest with deep, sharp notch. Wings broad without wing fold, darkened area wing opposite jaw angle broad. Shoulder tooth prominent, rounded. Broad, blunt angle point visible in single smaller specimen (LRL 5.8mm.) only. Clear strip present in one smaller specimen (LRL. 5.8mm.) between anterior margin of lateral wall and wing. Crest slightly curved, narrow, not cut but appears thickened. No lateral wall fold or ridge, may be infold either side of crest. Deep indentation of posterior darkened lateral wall to sides of crest.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of fresh specimens (ln WtF) in grams are:

ML = -153.88 + 98.88 LRL (r^2=1.00, n=4)
ln WtF = 4.62 + 2.52 ln LRL (r^2=1.00, n=2)

HISTIOTEUTHIDAE

Upper beak: There are no discernable differences between the upper beaks of the Histioteuthis spp. examined here.

Rostrum curved, rostral double edge present on inner surface. Jaw angle obtuse to 90°, with false angle formed by lateral wall extending forward of wing, wing forms posterior edge of false angle. Shoulder irregularly broken. Posterior hood/wing margin weakly convex. Wing extends nearly to base of anterior lateral wall margin. Shallow or no indentation of posterior margin of lateral wall.

Unlike many other families, even the size range of the beaks and darkening stages was found to be of little use. For each species, lateral walls darken by spread from crest. As can be seen below, there is great overlap between species in the size ranges at which this occurs. It is also worth noting, that there were no mature or fully darkened specimens examined for *H. eltaninae* and *H. reversa* as they were not available from the collection.

Species	UB size range	UB size at darkening
H. atlantica	URL 0.73 – 8.95	URL 1.12-2.32mm., fully darkened at URL 3.74mm.
H. bonnelli corpuscula	URL 0.80 – 4.09	URL 0.80-3.48mm., fully darkened at URL 4.07mm.
H. eltaninae	URL 0.56 – 2.93	URL 0.56-2.91mm., no fully darkened specimens examined
H. macrohista	URL 1.04 – 2.43	URL 1.04-1.58mm, fully darkened at URL 2.30mm.
H. miranda	URL 1.33 – 6.16	URL 1.33-2.25mm., fully darkened at URL 3.96mm.
H. reversa	URL 0.92 – 2.93	URL 1.38-3.08mm., no fully darkened specimens examined

For all histioteuthid upper beaks,

Calculated regressions of URL in mm. against mantle length (ML) in mm. is:

ML = 31.41 URL – 19.76 (r^2=0.79, n=98)

Regressions to estimate weight were not calculated for the combined pool of *Histioteuthis* spp. as there was a mixture of preserved specimen weights and fresh specimen weights recorded, species specific regressions are given below and in appendies 5 and 6.

Lower beak: Rostral edge curved, may have hook. Jaw angle obtuse to 90°. Hood notch shallow, broad. Wings broad with darkened area opposite jaw angle broad, wing fold present. Small shoulder tooth may be present. Angle point narrow, blunt, long in small specimens becoming shorter with growth, may not be visible in largest specimens. No step or clear strip between anterior margin of lateral wall and wing. Crest curved, narrow, thickened. Indentation of posterior darkened lateral wall margin to sides of crest very small or absent.

As shown by Clarke (1986) histioteuthid beaks can be split into those of Type A & B. Where A = distinct hood notch, well developed ridge running to free corner. B= shallow hood notch, weakly developed ridge (fold) running above free

corner.

For cases where a histioteuthid beak cannot be identified beyond that of type A or type B, calculated regressions for LRL in mm. against mantle length (ML) in mm. is given below for Type A beaks only.

Type A

ML = 33.37 LRL – 25.77 (r^2=0.92, n=60)

No significant relationships could be found from the combined specimens of Type B between LRL and mantle length. Species specific calculations are given below and in appendices 5 and 6.

Species	URL in mm. against mantle length (ML) in mm.	URL in mm. against total weight of preserved specimens (ln WtP) in grams
H. atlantica	ML = -19.40 + 33.14 URL (r^2=0.82, n=20)	ln WtP = 1.61 + 2.61 ln URL (r^2=0.88, n=18)
H. bonnelli corpuscula	ML = -3.48 + 17.08 URL (r^2=0.93, n=21)	ln WtP = 0.74 + 3.01 ln URL (r^2=0.86, n=21)
H. eltaninae	ML = -2.92 + 23.62 URL (r^2=0.99, n=6)	ln WtP = 0.30 + 3.26 ln URL (r^2=0.85, n=5)
H. macrohista	ML = -12.78 + 24.59 URL (r^2=0.99, n=8)	ln WtP = 0.56 + 4.08 ln URL (r^2=0.98, n=8)
H. miranda	ML = -42.04 + 42.06 URL (r^2=0.83, n=31)	ln WtF = 0.55 + 3.47 ln URL (r^2=0.96, n=22)
H. reversa	ML = 6.37 + 21.01 URL (r^2=0.85, n=12)	ln WtP = 1.44 + 2.42 ln URL (r^2=0.91, n=12)

Histioteuthis atlantica

Lower beak: Wings colourless at LRL 2.16mm., darken by spread along posterior wing at LRL 2.54mm., fully darkened at LRL 3.68mm. Jaw angle hidden from side by wing fold. Lateral wall fold thickened to form low ridge anteriorly, fold becomes broad posteriorly, reaches posterior margin above free corner. Ridge is longer and better defined in small specimens (wings colourless).

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -10.42 + 25.66 LRL (r2=0.89, n=21)

ln WtP = 1.49 +2.45 ln LRL (r2=0.91, n=19)

Histioteuthis bonnelli corpuscula

Lower beak: Wings colourless at LRL 2.33mm., darkening stage with large isolated patch on wings at LRL 3.04mm. which is joined to hood darkening at LRL 3.80mm., fully darkened at LRL 5.02mm. Jaw angle only just hidden by wing fold from side. Distinct lateral wall ridge (fin) heading towards, but not reaching, free corner.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 1.82 + 15.24 LRL (r^2=0.93, n=21)

ln WtP = 1.16 + 2.70 ln LRL (r^2=0.86, n=21)

Histioteuthis eltaninae

No mature specimens examined.

Lower beak: Wings colourless at LRL 1.10mm, darkening begins with formation of patch near posterior wing margin at LRL 2.5mm. which is connected to hood darkening at LRL 2.86mm. Jaw angle just hidden from side by wing fold. Lateral wall fold thickened anteriorly to form ridge, becoming broad posteriorly, reaching posterior lateral wall margin just above free corner.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -3.65 + 24.48 LRL (r^2=0.99, n=6)

ln WtP = 0.33 + 3.11 ln LRL (r^2=0.79, n=5)

Histioteuthis macrohista

Lower beak: Wings colourless at LRL 1.45mm, darkening process unknown, fully darkened at LRL 2.90mm. Jaw angle visible from side in most specimens, just hidden by low wing fold in largest specimen (LRL 3.10mm.). Distinct lateral wall ridge (fin) runs to free corner.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 2.36 + 14.46 LRL (r^2=0.96, n=8)

ln WtP = 1.16 + 2.72 ln LRL (r^2=0.96, n=8)

Histioteuthis miranda

Lower beak: Darkening process unknown, wings colourless at LRL 2.41mm., fully darkened at LRL 4.34mm. Jaw angle hidden from side by high wing fold. Distinct lateral wall ridge (fin) runs to free corner.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -26.51 + 34.21 LRL (r^2=0.86, n=31)

ln WtF = 0.86 + 3.04 ln LRL (r^2=0.95, n=22)

Histioteuthis reversa

No mature specimens examined.

Lower beak: Wings colourless at LRL 2.53mm, darkening begins with formation of patch along posterior wing margin at LRL 3.06mm. Jaw angle partly hidden from side by wing fold. Lateral wall fold thickened anteriorly to form ridge, becoming broad posteriorly, reaches posterior margin just above free corner.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 9.01 + 18.99 LRL (r^2=0.90, n=10)

ln WtP = 1.41 + 2.35 ln LRL (r^2=0.99, n=10)

BATHYTEUTHIDAE

Bathyteuthis abyssicola

Upper beak: Darkening process unknown, fully darkened at URL 0.78mm. Rostrum short, less than 1/3 length of hood. Jaw angle obtuse, curved. Hood short, ~ 0.6 length of crest. Posterior margin of hood/wing complex diagonal. Wing extends to base anterior margin of lateral wall. Two pigment stripes may be visible on inner surface of anterior crest. Lateral walls widely spread No indentation of posterior margin of lateral wall.

Calculated regressions of URL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -21.48 + 75.99 URL(r2=0.59, n=11)

ln WtP = 2.48 + 3.49 ln URL (r2=0.66, n=11)

Lower beak: Darkening stage with a large spot on wings connected by a thin isthmus to hood darkening at LRL 0.55mm. Rostral edge straight, short ~ ½ hood length, wide LRL/JW ~1. Jaw angle obtuse, visible or only just hidden by low wing fold from side. Hood broad, low on crest, without

notch. Wings broad with narrow pigmented area opposite jaw angle. No shoulder tooth, angle point, step, or clear strip present. Crest almost straight, wide, unthickened. No lateral wall fold or ridge, lateral walls widely spread. Deep indentation of posterior darkened lateral wall to sides of crest.

No significant relationship found between LRL and mantle length or total weight of preserved specimens in these specimens.

CTENOPTERYGIDAE

Ctenopteryx siculus
Pigmentation yellow/brown.

Upper beak: Lateral walls colourless at URL 1.04mm., fully darkened at URL 1.62mm., darkening process unknown. Rostrum curved, inner rostrum smooth without pigment stripes. Jaw angle close to 90°. Posterior margin of hood/wing complex slightly convex. Wing extends 2/3 length to base anterior margin of lateral wall. Crest wide, curved. Indentation of posterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -20.76 + 63.80 URL (r^2=0.84, n=13)
ln WtP = 1.44 + 4.21 ln URL (r^2=0.84, n=13)

Lower beak: Wings colourless at LRL 0.69mm., darkening stage with a small patch on wings connected to hood complex darkening by a fine isthmus at LRL 0.94mm., fully darkened at LRL 1.78mm. Rostrum wide LRL/JW ~1, rostral edge slightly curved, shorter than hood length. Jaw angle obtuse, visible from side. Broad hood without notch. Wings with low wing fold, pigmented area narrow opposite jaw angle, widely spread. Shoulder tooth absent, angle point absent. No step or clear strip between anterior margin of lateral wall and wing. Crest curved, unthickened. Lateral wall may have indistinct fold. Very slight or no indentation of posterior darkened lateral wall.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 9.85 + 36.10 LRL (r^2=0.77, n=13)
ln WtP = 1.64 + 2.53 ln LRL (r^2=0.81, n=13)

BRACHIOTEUTHIDAE

Brachioteuthis* cf. *riisei
Upper beak: Lateral walls darken by spread at URL 1.02-1.32mm., fully darkened at URL 1.65mm. Rostrum curved, with broad rostral edge. Jaw angle obtuse with distinctive, elongate false angle. Hood short, ≤2/3 crest length, short step immediately posterior to jaw angle. Posterior margin of hood/wing complex convex. Wing extends nearly to base of lateral wall anterior margin. Crest almost straight, lateral walls touching in dissected specimens. Indentation of posterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 13.57 + 22.66 URL (r^2=0.91, n=24)
ln WtP = -0.16 + 2.46 ln URL (r^2=0.92, n=24)

Lower beak: Wings colourless at LRL 1.66mm., darkening stage with an isolated spot on wings at LRL 1.85-1.94mm., fully darkened at LRL 2.04mm. Curved rostrum protruding forwards, approximately equal to hood length. Jaw angle obtuse, visible from side. Hood low on crest, may have broad, shallow notch, or notch absent. Darkened area of wing narrow opposite jaw angle, no wing fold. Angle point broad, blunt, not visible in larger specimens. No step or clear strip present between anterior lateral wall and wing. Crest curved, narrow and thickened. Lateral wall ridge (distinct knob in cross section) almost reaching free corner. Free corner drawn out, lower margin of lateral wall distinctly curved. Slight, blunt indentation of posterior darkened lateral wall.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 7.69 + 23.06 LRL (r^2=0.94, n=25)
ln WtP = -0.81 + 2.94 ln LRL (r^2=0.90, n=25)

OMMASTREPHIDAE

Upper beak: Rostrum curved. Jaw edge may be broken or smooth, jaw angle acute, recessed in all except O. volatilis. Clear strip in hood extending posteriorly from jaw angle, becoming less defined with growth/darkening. Posterior margin of hood/wing complex convex. Crest slightly curved. Indentation of posterior margin of lateral wall.

Lower beak: Rostral edge curved, or straight with a small hook. Jaw angle acute. Shoulder tooth or ridge present. Clear strip present between anterior margin of lateral wall and wing in all but largest specimens. Crest slightly curved, narrow, may be infold to either side. Unthickened lateral wall fold, extending to posterior margin, may be indistinct or absent. Small, angular indentation of darkened posterior lateral wall to sides of crest.

Todaropsis eblanae
Upper beak: Lateral walls colourless at URL 4.15mm., isolated spot present on walls at URL 5.10-5.78mm., but can be fully darkened at URL 5.58mm. Inner rostral surface smooth. Wing extends halfway to base anterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -36.98 + 32.42 URL (r^2=0.90, n=28)
ln WtP = 2.92 ln URL (r^2=0.94, n=24)

Lower beak: Wings colourless at LRL 3.94mm., small isolated patch present on wings of a single specimen at LRL 4.17mm., fully darkened at LRL 4.60mm. Rostrum wide (LRL/JW ~ 1). Jaw angle acute, recessed, visible from side. Hood normal on crest, with deep, broad notch. Wings without wing fold. Shoulder tooth ridge-like. Angle point narrow, blunt, almost reaching margin of darkened lateral wall in small specimens, indistinct in larger specimens. Crest thicker than lateral wall to either side. Lateral wall fold reaches posterior margin above halfway between crest and free corner.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -37.43 + 34.90 LRL (r^2=0.91, n=28)
ln WtP = -0.03 + 3.11 ln LRL (r^2=0.96, n=24)

Todarodes filippovae
Upper beak: Lateral walls may be colourless at URL 8.22mm., darkening stage with an isolated spot on walls at URL 5.67-10.62mm., fully darkened at URL 10.68mm. Double ridge/groove pattern on inner rostrum surface, may be

worn in larger specimens. Wing extends halfway to base of lateral wall anterior margin.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of fresh specimens (ln WtF) in grams are:

ML = 56.29 + 32.28 URL (r^2=0.80, n=101)

ln WtF = 0.64 + 2.78 ln URL (r^2=0.86, n=88)

Lower beak: Wings colourless at LRL 6.40mm.,darkening stage with an isolated spot on wing at LRL 6.62-8.04mm., but can be fully darkened at LRL 5.88m. Rostral edge about same length as hood. Jaw angle acute, recessed, partly hidden from side by wing fold. Broad hood low on crest with deep, rounded notch. Wings broad, widely spread with low, thickened wing fold. Crest thickened. Shoulder tooth ridge-like, broken. Angle point narrow, blunt not reaching lower darkened margin of lateral wall. Lateral wall fold reaches posterior margin halfway between crest and free corner. Sharp indentation of posterior darkened lateral wall to sides of crest.

Calculated regressions LRL in mm. against mantle length (ML) in mm. and total weight of fresh specimens (ln WtP) in grams are:

ML = 46.07 + 33.97 LRL (r^2=0.82, n=101)

ln WtP = 0.69 + 2.78 ln LRL (r^2=0.87, n=88)

Nototodarus gouldi

Upper beak: Lateral walls colourless at URL 4.92mm., isolated spot on lateral wall at URL 5.28-9.21mm., spot joined with darkening from crest at URL 9,26mm. Double ridge/groove pattern on inner surface of rostrum, may be greatly worn in larger specimens. Wing extends halfway to base of lateral wall anterior margin.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of fresh specimens (ln WtF) in grams are:

ML = 57.75 + 29.90 URL (r^2=0.86, n=93)

ln WtF = 1.02 + 2.67 ln URL (r^2=0.92, n=67)

Lower beak: Darkening stage with an isolated spot on wing at LRL 3.70-4.63mm., fully darkened at LRL 5.82mm. Jaw angle acute, recessed, partly hidden from side view if wing fold present. Broad hood normal on crest, with deep, blunt notch. Wings broad, widely spread, may have low, thickened wing fold. Ridge-like tooth on shoulder, may be jagged. Angle point blunt, not reaching lower darkened margin of lateral wall. Crest slightly thickened, may be infold to either side. Lateral wall fold reaches posterior margin above halfway between crest and free corner, may be indistinct or absent.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of fresh specimens (ln WtF) in grams are:

ML = 41.88 + 33.99 LRL (r^2=0.91, n=91)

ln WtF = 0.80 + 2.86 ln LRL (r^2=0.94, n=67)

Ommastrephes bartrami

Upper beak: Lateral walls colourless at URL 5.25mm., darkening stage with an isolated spot on lateral wall occurs at URL 5.24-10.95mm. Double ridge/groove pattern on inner rostrum surface Hood long extending 0.83 length of crest Wing extends ½ length to base anterior margin of lateral wall.

Calculated regressions of URL in mm. against mantle length (ML) in mm., fresh (ln WtF) and preserved (ln WtP) weights in grams are:

ML = 22.42 + 34.69 URL (r^2=0.95, n=29)

ln WtF = 2.57 + 1.95 ln URL (r^2=0.95, n=5)

ln WtP = 0.92 + 2.76 ln URL (r^2=0.98, n=24)

Lower beak: Wings colourless at LRL 5.08mm., darkening stage with an isolated spot on wing occurs at LRL 5.33-6.89mm., spot becoming joined to hood darkening at LRL 6.08-7.06mm. Jaw angle acute, recessed, visible from side. Hood low on crest, with deep, forked notch in larger specimens, shallow notch in specimens with colourless wings. Wings broad with very low, or no, wing fold. Shoulder tooth rounded, broken. Angle point blunt, not reaching lower darkened margin of lateral wall, indistinct in larger specimens. Crest thickened. Lateral wall fold reaches posterior margin above halfway between crest and free corner.

Calculated regressions of LRL in mm. against mantle length (ML) in mm., fresh (ln WtF) and preserved (ln WtP) weights in grams are:

ML = 16.12 + 37.73 LRL (r^2=0.95, n=29)

ln WtF = 1.95 + 2.35 ln LRL (r^2=0.99, n=5)

ln WtP = 0.93 + 2.83 ln LRL (r^2=0.98, n=24)

Eucleoteuthis luminosa

Upper beak: Lateral walls may be colourless at URL 3.48mm., isolated spot may be present at URL 2.99-3.02mm, spot joined to crest darkening at URL 4.07-4.20mm. Double ridge/groove pattern on inner rostrum surface. Hood long extending 0.82 length of crest. Wing extends 2/3 length to base anterior margin of lateral wall.

Calculated regressions of URL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 18.55 + 33.78 URL (r^2=0.94, n=25)

ln WtP = 1.13 + 2.16 ln URL (r^2=0.93, n=25)

Lower beak: Wings colourless at LRL 2.44mm., darkening stage with isolated spot on wings at LRL 2.92-3.50mm., fully darkened at LRL 4.43mm. Jaw angle acute, may be slightly recessed, partly hidden from side if wing fold present. Hood normal on crest with shallow notch. Shoulder tooth small or absent. Angle point blunt, short. Crest not thickened Lateral wall fold reaching posterior margin halfway between crest and free corner.

Calculated regressions of LRL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 19.42 + 33.18 LRL (r^2=0.96, n=25)

ln WtP = 1.14 + 2.15 ln LRL (r^2=0.97, n=25)

Ornithoteuthis volatilis

Upper beak: Lateral walls colourless at URL 4.01mm., fully darkened at URL 5.42mm. but large colourless margin remains. Inner rostrum surface smooth. Jaw angle close to 90°, may have small false angle, not recessed. Wing extends 2/3 length to base of lateral wall anterior margin.

Calculated regressions of URL in mm. against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 4.39 + 33.53 URL (r^2=0.93, n=39)

ln WtP = 0.72 + 2.25 ln URL (r^2=0.97, n=40)

Lower beak: Wings may be colourless at LRL 3.81mm., darkening stage with isolated spot on wings at LRL 3.67-4.00mm., fully darkened at LRL 5.12mm. Jaw angle acute, slightly recessed, visible from side. Hood normal on crest, with broad notch. Small rounded tooth on shoulder. Angle point narrow, not extending to dorsal margin of lateral wall. Crest short, HL/CL > ½ , unthickened. Lateral wall fold reaches posterior margin halfway between crest and free corner.

Calculated regressions of LRL in mm. against mantle length

(ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 2.58 + 33.74 LRL (r^2=0.95, n=39)
ln WtP = 0.68 + 2.27 ln LRL (r^2=0.97, n=40)

MASTIGOTEUTHIDAE

Mastigoteuthis cordiformis
Upper beak: Lateral walls darken by spread from crest at URL 6.55-9.44mm. fully darkened at URL 10.33mm. Double edge present on inner rostral surface, rostrum short URL/UHL<1/3. Jaw angle obtuse with false angle. Wing extends halfway to base anterior margin of lateral wall. Indentation of posterior margin of lateral wall.

No relationship was found between URL and mantle length in these specimens. Calculated regression of URL in mm. against total weight of fresh specimens (ln WtF) is:

ln WtF = -5.19 + 5.86 ln URL (r^2=0.95, n=5)

Lower beak: Wings colourless at LRL 7.74mm., large isolated spot on wings at LRL 9.48mm., fully darkened at LRL 13.36mm. Rostral edge curved, shorter than hood, rostrum narrow LRL/LJW~1.5-1.7. Jaw angle varies from acute, recessed when shoulder tooth present, to obtuse when shoulder tooth absent. Hood low on crest with deep notch. Wings with broad darkened area opposite jaw angle. Angle point blunt, not reaching lower darkened lateral wall margin, not visible in largest specimens. Crest unthickened Lateral wall fold reaching posterior margin halfway between crest and free corner.

No relationship was found between LRL and mantle length in these specimens. Calculated regression of LRL in mm. against total weight fresh specimens (ln WtF) is:

ln WtF = -3.53 + 4.67 ln LRL(r^2=0.99, n=5)

CRANCHIIDAE

Cranchia scabra
Darkening process unknown, large colourless margin in all specimens examined. Pigmentation pale yellow/ brown.
Upper beak: Inner rostral surface smooth, without pigment stripes. Jaw angle acute, may be slightly recessed. Posterior margin hood/wing complex convex. Wing extends nearly to base anterior margin of lateral wall. Crest curved. Indentation of posterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 33.37 + 35.29 URL (r^2=0.74, n=17)
ln WtP = 1.77 + 2.02 ln URL (r^2=0.87, n=16)

Lower beak: Rostral edge curved, short, ~0.7 hood length. Jaw angle acute, recessed, visible from side. Hood with shallow or no notch. Shoulder tooth large, rounded. Angle point sharp, short. Clear strip visible between anterior margin lateral wall and wing. Crest wide, unthickened. No lateral wall fold or ridge. Indistinct indentation of posterior darkened lateral wall to sides of crest.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 35.94 + 35.26 LRL (r^2=0.82, n=18)
ln WtP = 1.93 + 1.88 ln LRL (r^2=0.90, n=17)

Liocranchia reinhardti
Darkening process unknown, large colourless margin in all specimens examined. Pigmentation pale yellow/ brown.
Upper beak: Inner rostrum smooth without pigment stripes. Jaw angle obtuse to 90°. Posterior margin of hood/wing complex convex. Wing extends 2/3 length anterior margin of lateral wall. Indentation of posterior margin lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams is:

ML = 41.02 + 37.19 URL (r^2=0.57, n=26)
ln WtP = 1.13 + 2.28 ln URL (r^2=0.91, n=26)

Lower beak: Rostral edge curved. Jaw angle acute, recessed, partially hidden from side by wing fold. Hood low on crest, with shallow or no notch. Shoulder tooth pointed. Angle point blunt, narrow. Darkened area of wing opposite jaw angle narrow. Indistinct clear strip may be present between anterior margin of lateral wall and wing. Crest almost straight, wide, unthickened. No lateral wall fold or ridge. No indentation of posterior margin of lateral wall.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 40.23 + 38.72 LRL (r^2=0.56, n=27)
ln WtP = 1.23 + 2.27 ln LRL (r^2=0.92, n=27)

Megalocranchia abyssicola
Upper beak: Darkening process unknown, lateral walls colourless at URL 6.20mm., fully darkened at URL 8.30mm. Inner rostrum smooth. Jaw angle 90°, or acute and slightly recessed. Hood long, UHL/UCL> 0.8. Posterior margin hood/wing complex convex. Wing extends halfway to base anterior margin of lateral wall. No indentation of posterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -29.39 + 51.02 URL(r^2=0.78, n=9)
ln WtP = -0.43 + 2.69 ln URL (r^2=0.98, n=9)

Lower beak: Darkening process unknown, wings colourless at LRL 5.44mm, fully darkened at LRL 8.00mm. Rostrum curved, narrow (LRL/JW >1.5), equal or longer than hood length. Jaw angle obtuse, hidden from side view by wing fold. Hood low on crest, with deep notch. Darkened area of wing broad opposite jaw angle Shoulder tooth very small or absent. Angle point broad, not visible in largest specimen (LRL 8.00mm.). Crest curved, thicker than lateral wall to either side. Lateral wall fold reaches posterior margin halfway between crest and free corner. Small indentation of posterior darkened lateral wall to sides of crest.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = -25.07 + 52.15 LRL (r^2=0.75, n=9)
ln WtP = -0.28 + 2.66 ln LRL(r^2=0.97, n=9)

Sandalops melancholicus
Upper beak: Darkening process unknown, lateral walls fully darkened at URL 1.64mm. Rostrum long, URL/UHL~0.4, double edge at inside shoulder only. Jaw angle obtuse, with large false angle, not recessed. Wing extends nearly to base anterior margin of lateral wall. Two long pigment stripes on inner surface of crest. Crest normal width, slightly curved.

Shallow indentation of posterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 6.69 + 37.82 URL (r^2=0.79, n=9)

ln WtP = 0.56 + 2.29 ln URL (r^2=0.76, n=9)

Lower beak: Darkening process unknown, wings colourless at LRL 1.62mm., fully darkened at LRL 1.75mm. Rostral edge slightly curved, approximately same length as hood. Jaw angle 90°, hidden from side by wing fold. Broad hood low on crest, without notch. Shoulder tooth small or absent. Angle point broad, blunt. Crest curved, narrow, unthickened. No lateral wall fold or ridge, though midsection of wall slightly thickened. No indentation of posterior margin of lateral wall.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 12.24 + 32.56 LRL (r^2=0.87, n=9)

ln WtP = 0.49 + 2.32 ln LRL (r^2=0.96, n=9)

Teuthowenia pellucida

Upper beak: Lateral walls darken by spread from the crest at URL 1.06-3.06mm., fully darkened at URL 3.60mm. Jaw angle obtuse to 90°, distinct false angle may be present in large specimens. Lateral wall extends anterior of wing, forming a 'tooth' or false angle. Posterior margin hood/wing complex convex. Wing extends nearly to base of lateral wall anterior margin. Small indentation of posterior margin of lateral wall.

Calculated regressions of URL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 19.94 + 32.37 URL (r^2=0.90, n=42)

ln WtP = 0.76 + 1.98 ln URL (r^2=0.95, n=42)

Lower beak: Wings colourless at 2.60mm., darkening stage with isolated spot on wing at LRL 2.66-3.14mm., spot is connected to hood darkening at LRL 3.16mm. Rostrum generally narrow, LRL/LJW >1.5. Jaw angle obtuse to 90°, visible from side. Hood low on crest with broad, shallow notch. Small ridge-like shoulder tooth may be present. Crest curved, narrow, unthickened. Well defined lateral wall fold with some thickening, reaches posterior margin halfway between crest and free corner. Very small, or no indentation of posterior darkened lateral wall to sides of crest.

Calculated regressions of LRL in mm., against mantle length (ML) in mm. and total weight of preserved specimens (ln WtP) in grams are:

ML = 22.27 + 29.90 LRL (r^2=0.86, n=41)

ln WtP = 0.71 + 1.94 ln LRL (r^2=0.95, n=41)

6.3 ORDERS OCTOPODA AND VAMPYROMORPHA

Key for identification of southern Australian Octopoda and Vampyromorpha upper beaks

1 Hood short, UHL/UCL<0.5, posterior hood/wing margin straight or concave ....2 ... Octopodidae
– Hood not short, UHL/UCL>0.5, posterior hood/wing margin convex 4
2 Slight or no indentation of posterior margin of lateral wall.. *Octopus kaurna, Hapalochlaena maculosa, Eledone palari*
– Obvious indentation of posterior margin of lateral wall.....3
3 Wing extends ½, 2/3 maximum depth lateral wall ....*Octopus berrima, Octopus maorum, Octopus warringa*
– Wing extends nearly to maximum depth of lateral wall ....*Octopus bunarong, Octopus pallidus,* .... *Octopus superciliosus*
4 Posterior lateral wall margin with large indentation and large colourless margin ....*Ocythoe turberculata, Argonauta nodosa*
– No indentation of posterior lateral wall margin, small colourless margin 5
5 Jaw angle distinct, obtuse with false angle, double edge on inner rostrum.............................. *Vampyroteuthis infernalis*
– Jaw angle absent, inner rostrum with broad edge................ .... *Grimpoteuthis* sp., *Opisthoteuthis* sp.

Key for identification of southern Australian Octopoda and Vampyromorpha lower beaks

1 Hood and wings very broad. Hood long LHL/LCL 0.8-0.9. .... *Vampyroteuthis infernalis*
– Hood and wings not broad. Hood not as long as above LHL/LCL <0.7.. 2
2 Lateral wall fold present ....3. Octopodidae
– No lateral wall fold 9
3 Deep, wide midline indentation of posterior lateral wall margin, extending almost to posterior hood margin when viewed from above.....................*Hapalochlaena maculosa*
– Midline indentation of posterior lateral wall margin does not extend almost to posterior hood margin when viewed from above 4
4 Lateral wall fold reaches lower margin halfway. In mature specimens, wing pigmentation does not narrow opposite position of jaw angle in squid ....*Octopus kaurna*
– Lateral wall fold reaches lower margin anterior to free corner (but greater than halfway). In mature specimens, if wing pigmentation present, narrows opposite position of jaw angle in squid 5
5 Rostrum to shoulder and leading wing edge, i.e. cutting edge, straight. Wings colourless, even in mature specimens ....*Eledone palari*
– Cutting edge curved. Wings of mature specimen pigmented 6
6 Rostral tip broad, usually indented. Posterior indentation of darkened lateral wall margin shallow and blunt, may be squarish .... *Octopus berrima, Octopus pallidus,* ....*Octopus warringa, Octopus supercilious*
– Rostral tip narrower, not indented. Posterior indentation of darkened lateral wall margin deeper than above .... *Octopus bunarong, Octopus maorum*
9 Large colourless margin of posterior lateral wall even in mature specimens.. ....*Ocythoe turberculata, Argonauta nodosa*
– Small colourless margin of posterior lateral wall................ .... *Grimpoteuthis* sp., *Opisthoteuthis* sp.

Southern Australian Octopoda and Vampyromorpha beak descriptions including equations for the back-calculation of length and mass.

Calculated regressions for the estimation of weight are generally much better than those for mantle length for the members of the Orders Octopoda and Vampyromorpha. This is due to the difficulty in taking accurate measurements of mantle length from preserved specimens (used to generate the calculations), which without a gladius or cuttlebone to support the mantle, have usually contracted on preservation.

ORDER OCTOPODA

Upper beak: Jaw angle absent, or rarely obtuse. No clear strip in hood. Shoulder edge not distinctly rounded as in many teuthids.
Lower beak: Hood without notch, or rarely shallow notch. Shoulder tooth absent, angle point absent. No clear strip or step between anterior margin of lateral wall and wing. Wings without wing fold. Free corners of lateral walls widely spread.

SUBORDER CIRRATA

The three species *Grimpoteuthis* sp. (Family Grimpoteuthidae), *Opistoteuthis persephone* and *Opisthoteuthis pluto* (Family Opisthoteuthidae) examined here share many characteristics.

Upper beak: Darkening process unknown, with the lateral walls of the smallest specimen examined for each species (*Grimpoteuthis* sp. UHL 9.1mm., *Opisthoteuthis persephone* UHL 4.4mm., *Opisthoteuthis pluto* UHL 6.4mm.) pigmented. Rostral edge only slightly curved, pointed tip, cutting edge smooth. Rostrum with broad inner edge, resembling double edge but without grooves, inner surface smooth. Hood long ~0.6-0.7 crest length. Posterior margin of hood/wing complex convex. Wing extends to base anterior margin of lateral wall. Crest not wide, straight for most of length, unthickened. Lateral walls spread parallel, no indentation of posterior margin. Additionally, the lateral walls of *Opisthoteuthis* spp. specimens may have an infold reaching the posterior margin halfway between the crest and lower lateral wall margin, but this is not a consistent feature.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

Grimpoteuthis sp.	ML = -86.13 + 14.42 UHL (r^2=0.90, n=3)	
Opisthoteuthis persephone	ML = -9.34 + 4.37 UHL (r^2=0.77, n=33)	ln WtP = -2.34 + 3.51 ln UHL (r^2=0.94, n=34)
Opisthoteuthis pluto	ML = -6.40 + 5.31 UHL (r^2=0.82, n=7)	ln WtP = -0.24 + 2.79 ln UHL (r^2=0.66, n=7)

Lower beak: Rostrum pinched, edge curved, tip blunt without midline indentation. Cutting edge smooth. Broad hood high on crest, may have shallow notch. Wings broad. Crest straight for most of length, unthickened, approximately equal length to LRF and LBL. No lateral wall fold or ridge. Generally no midline indentation of posterior darkened lateral wall, rarely a shallow square indentation.

GRIMPOTEUTHIDAE

***Grimpoteuthis* sp.**
Only three specimens examined.
Lower beak: Darkening process unknown, wings darkened at LHL 5.2mm., darkened part of wing narrower opposite area where jaw angle would be found in squid. Jaw angle absent.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) is:

ML = -121.28 + 31.36 LHL (r^2=0.84, n=3)

OPISTHOTEUTHIDAE

Opisthoteuthis spp.
Lower beak: Darkening process unknown with the wings of the smallest beak examined of each species pigmented at LHL 2.6mm. for O. persephone and LHL 4.0mm for O. pluto. Jaw angle obtuse or absent. *O. persephone* may have one or more irregular thickened striations (ridges) running along lateral walls or crest, not reaching posterior margin. These were not present in *O. pluto* examined, but again the feature is not consistent in all *O. persephone* specimens and cannot be used to separate the species.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

O. persephone	ML = -7.84 + 6.74 LHL (r^2=0.81, n=33)	ln WtP = -0.42 + 3.36 ln LHL (r^2=0.95, n=34)
O. pluto	ML = 2.79 + 5.98 LHL (r^2=0.79, n=7)	ln WtP = 1.86 + 2.16 ln LHL (r^2=0.65, n=7)

SUBORDER INCIRRATA

Upper beak: Inner rostrum smooth, without double edge or pigment stripes.

OCTOPODIDAE

Upper beak: Rostrum wide, blunt tip. Hood short ~0.4 crest length. Posterior margin of hood/wing complex straight or weakly concave. Crest wide, lateral walls widely spread.
Lower beak: Rostrum tip blunt, rostral edge-shoulder joint curved or straight. Hood low on crest. Wings parallel to widely spread. Crest wide, shorter than LRF. Midline indentation of posterior darkened margin of lateral wall, no indentation to sides of crest as seen in most teuthids.

Octopus
Upper beak: Darkening process unknown. Rostral edge curved. Crest curved.
Lower beak: Wing pigmentation narrows at area of jaw angle in squid in all except Octopus kaurna.

Octopus berrima
Upper beak: Lateral walls darkened at UHL 1.9mm. Wing extends half maximum depth of lateral wall. Crest just thicker than lateral wall to either side. Lateral wall fold reaching posterior margin below indentation may be present.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and preserved weight (WtP) in grams are:

ML = -11.58 + 15.99 UHL (r^2=0.65, n=35)
ln WtP = -0.44 + 3.53 ln UHL (r^2=0.77, n=35)

Lower beak: Wings darken by spread with straight inner edge, pigmented at LHL 1.4mm. Rostrum tip broad, indented. Hood curved in profile. Crest curved, unthickened. Lateral wall fold reaches lower margin just anterior to free corner. Midline indentation of posterior darkened lateral wall generally shallow and broad.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -10.08 + 20.05 LHL (r^2=0.86, n=36)

ln WtP = 0.75 + 3.23 ln LHL (r^2=0.89, n=36)

Octopus bunurong

Upper beak: Lateral walls darkened at UHL 1.0mm. Wing extends nearly to maximum depth of lateral wall. Crest unthickened.

No significant relationship found between UHL and mantle length in these specimens. Calculated regression of UHL in mm. against total weight of preserved specimens (WtP) in grams is:

ln WtP = -0.21 + 3.15 ln UHL (r^2=0.85, n=11)

Lower beak: Wings darken by spread with straight inner edge at LHL 0.9-1.8mm., fully darkened at LHL 2.1mm. Rostral tip narrow without indentation. Hood flat in profile. Crest straight, unthickened. Lateral wall fold reaches lower lateral wall margin anterior to free corner. Deep, blunt midline indentation of posterior darkened lateral wall.

No significant relationship found between LHL and mantle length in these specimens. Calculated regression of UHL in mm. against total weight of preserved specimens (WtP) in grams is:

ln WtP = 0.50 + 3.51 ln LHL (r^2=0.83, n=11)

Octopus kaurna

Upper beak: Lateral walls pigmented from UHL 1.0mm. Wing extends 2/3 maximum depth of lateral wall. Crest unthickened. Lateral wall indentation not as obvious as in other Octopus species examined.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 0.72 + 18.54 UHL (r^2=0.28, n=25)

ln WtP = 1.14 + 2.77 ln UHL (r^2=0.66, n=25)

Lower beak: Wings usually colourless between LHL 0.9-1.3mm., darken by spread with indistinct edges at LHL 1.3-2.1mm. This is the only octopod species examined in which the wing pigmentation does not narrow opposite the position of the jaw angle in teuthids. Rostral tip broad, may have shallow indentation. Hood flat in profile. Crest straight, unthickened. Weak lateral wall fold reaches lower margin halfway to free corner. Deep, blunt midline indentation of posterior darkened lateral wall margin.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -9.10 + 29.54 LHL (r^2=0.39, n=28)

ln WtP = 1.67 + 2.99 ln LHL (r^2=0.64, n=28)

Octopus maorum

Upper beak: Lateral walls darkened at UHL 2.4mm. Wing extends 2/3 maximum depth of lateral wall. Crest unthickened. May be weak fold in lateral wall reaching posterior margin below indentation.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -55.57 + 20.67 UHL (r^2=0.72, n=17)

ln WtP = 0.73 + 2.64 ln UHL (r^2=0.88, n=12)

Lower beak: Wings colourless at LHL 1.3mm., darken by spread with straight inside edge from LHL 2.6mm. Narrow rostral tip without indentation. Hood flat in profile, may have shallow notch. Crest almost straight, unthickened. Lateral wall fold reaches lower margin anterior to free corner. Deep, sharp midline indentation of posterior darkened lateral wall margin.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -43.69 + 29.18 LHL (r^2=0.74, n=17)

ln WtP = 2.14 + 2.50 ln LHL (r^2=0.91, n=12)

Octopus pallidus

Upper beak: Lateral walls darkened at UHL 1.5mm. Wing extends nearly to maximum depth of lateral wall. Crest just thicker than lateral wall to either side.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -14.41 + 15.44 UHL (r^2=0.68, n=42)

ln WtP = -0.55 + 3.21 ln UHL (r^2=0.89, n=26)

Lower beak: Wings darken by spread with straight inside edge, pigmented from LHL 1.1mm. Rostral tip broad with shallow, or no indentation. Hood curved in profile. Crest unthickened, curved. Lateral wall fold reaches lower margin anterior to free corner. Midline indentation of posterior darkened lateral margin wall usually broad and shallow, occasionally shallow and square.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -14.73 + 22.45 LHL (r^2=0.69, n=42)

ln WtP = 0.47 + 3.41 ln LHL (r^2=0.96, n=26)

Octopus superciliosus

Upper beak: Lateral walls darkened from UHL 1.5mm. Wing extends nearly to maximum depth of lateral wall. Crest unthickened.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -9.02 + 14.56 UHL (r^2=0.84, n=10)

ln WtP = -0.99 + 3.84 ln UHL (r^2=0.86, n=10)

Lower beak: Wings pigmented at LHL 1.0mm. Rostral tip broad, may have shallow indentation. Crest almost straight, unthickened. Lateral wall fold reaches lower margin anterior to free corner. Wide midline indentation of posterior darkened lateral wall margin.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -6.25 + 18.20 LHL (r^2=0.92, n=10)

ln WtP = 0.47 + 3.22 ln LHL (r^2=0.90, n=10)

Octopus warringa

Upper beak: Lateral walls darkened at UHL 1.4mm. Wing extends 2/3 maximum depth of lateral wall. Crest unthickened.

No significant relationship found between UHL, or other upper beak dimensions, and mantle length. Calculated regression of UHL in mm. against total weight of preserved specimens (WtP) in grams is:

ln WtP = -0.41 + 3.20 ln UHL (r^2=0.61, n=11)

Lower beak: Darkening process unknown, wings darkened at LHL 0.9mm. Wing darkening narrows at area of jaw angle in squid. Rostral tip broad, may be indented in the midline. Crest almost straight, thickened anteriorly. No lateral wall fold or ridge. Shallow/medium blunt midline indentation of posterior lateral wall.

No significant relationship found between LHL, or other lower beak dimensions, and mantle length. Calculated

regression of LHL in mm. against total weight of preserved specimens (WtP) in grams is:

ln WtP = 1.06 + 1.79 ln LHL (r^2=0.43, n=10)

Hapalochlaena maculosa

Upper beak: Lateral walls pigmented at UHL 0.8mm. Hood low on crest. Wing extends 3/4 maximum depth of lateral wall. Crest unthickened. No fold in lateral wall, shallow indentation of posterior margin of lateral wall.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 17.05 + 4.06 UHL (r^2=0.24, n=31)

ln WtP = 1.00 + 2.89 ln UHL (r^2=0.60, n=31)

Lower beak: Wings pigmented from LHL 0.7mm. Rostral tip broad, may have shallow indentation, cutting edge may be irregularly broken. Hood flat in profile. Crest straight, unthickened. Lateral wall fold reaches lower margin halfway. Very deep, wide midline indentation of posterior darkened lateral wall margin, extending almost to posterior hood margin when viewed from above.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 16.97 + 5.57 LHL (r^2=0.25, n=31)

ln WtP = 1.92 + 2.67 ln LHL (r^2=0.64, n=31)

Eledone palari

Upper beak: Lateral walls fully darkened at UHL 1.2mm. Rostral edge to tip almost straight. Wing extends half maximum depth of lateral wall. Rostrum to wing tip long compared to hood, URW/UHL ~1.5. Crest unthickened. Shallow or no indentation of posterior margin of lateral wall.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -14.67 + 33.84 UHL (r^2=0.46, n=11)

ln WtP = 1.74 + 3.72 ln UHL (r^2=0.78, n=11)

Lower beak: Darkening process unknown, wings remain colourless in largest specimen examined, LHL 1.9mm. Rostral tip broad may have shallow indentation, cutting edge may be irregularly broken. Hood flat in profile. Crest straight, unthickened. Lateral wall fold reaching lower margin anterior to free corner, may be some thickening of lateral wall. Shallow to deep, wide midline indentation of posterior darkened lateral wall margin.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -7.62 + 31.71 LHL (r^2=0.67, n=11)

ln WtP = 2.30 + 3.05 ln LHL (r^2=0.87, n=11)

PELAGIC OCTOPODS (non - cirrate)

Chitin thin, brittle, large colourless margin even in mature specimens.

Upper beak: Cutting edge may be broken. Hood broad, ~0.6 crest length. Posterior margin of hood/wing complex weakly convex. Wing extends nearly to maximum depth of lateral wall. Large indentation of posterior margin.

Lower beak: Rostral tip narrow, pinched, rostral edge curved. Jaw angle absent or obtuse, cutting edge broken. Broad hood low on crest. Wings broad. Crest wide, unthickened, slightly curved. Lateral wall infold reaching lateral wall margin anterior to free corner. No indentation to sides of crest of posterior lateral wall margin as in most teuthids

OCYTHOIDAE

Ocythoe turberculata

Upper beak: Darkening by spread along crest and down lateral walls. Rostrum tip pointed, sharp, curving strongly downwards. Crest wide, not thickened.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 0.83 + 4.47 UHL (r^2=0.92, n=16)

ln WtP = -2.14 + 2.67 ln UHL (r^2=0.93, n=16)

Lower beak: Darkening process unknown, wings darkened from LHL 2.4mm. Deep midline indentation of colourless posterior lateral wall margin, may also be corresponding indentation of posterior darkened lateral wall.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = 2.27 + 5.82 LHL (r^2=0.91, n=16)

ln WtP = -1.05 + 2.51 ln LHL (r^2=0.90, n=16)

ARGONAUTIDAE

Argonauta nodosa

Only female specimens examined.

Upper beak: Darkening process unknown, lateral walls darkened from UHL 8.8mm. Rostrum with small, pointed tip. Crest wide, slightly thicker than lateral wall to either side.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -86.13 + 16.76 UHL (r^2=0.72, n=10)

ln WtP = -1.69 + 2.86 ln UHL (r^2=0.67, n=10)

Lower beak: Darkening process unknown, wings darkened from LHL 4.9mm. Slight squarish or no midline indentation of posterior darkened and undarkened lateral wall margins.

Calculated regressions of LHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

ML = -69.15 + 22.07 LHL (r^2=0.93, n=12)

ln WtP = -1.20 + 3.13 ln LHL (r^2=0.84, n=12)

ORDER VAMPYROMORPHA

VAMPYROTEUTHIDAE

Vampyroteuthis infernalis

Upper beak: Darkening process unknown, lateral walls pigmented at UHL 5.7mm. Rostrum long, curved, tip pointed, distinct double edge present on inner surface. Jaw angle obtuse, lateral wall extends forward of wing forming large, distinct false angle. Hood long as in many teuthids ~0.8 crest length. Posterior margin of hood/wing complex convex. Wing extends to base anterior margin of lateral wall. Crest straight, unthickened. No indentation of posterior margin of lateral wall.

Calculated regressions of UHL in mm. against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are: URW/UHL ~0.5, short compared to hood

length

$ML = 5.07 + 3.57\ UHL$ (r^2=0.56, n=11)

$\ln WtP = -3.49 + 3.09 \ln UHL$ (r^2=0.83, n=11)

Lower beak: Darkening process unknown, wings pigmented at LHL 4.4mm. Rostral tip pointed may have small hook. Broad hood without notch, covering ~ 0.9 length of crest. Wings very broad, darkened area does not narrow opposite jaw angle. Wings spread parallel with very high wing fold, highest opposite jaw angle, forming smooth cutting edge. Crest short, wide, unthickened. Jaw angle acute, may be slightly recessed, hidden in profile by wing fold. Shoulder tooth absent, angle point absent. Step between anterior margin of lateral wall and wing. Infold present in lateral wall to free corner, free corners widely spread. No indentation of posterior darkened lateral wall to sides of crest.

Calculated regressions of in mm., against mantle length in mm. (ML) and total weight of preserved specimens (WtP) in grams are:

$ML = 5.86 + 4.70\ LHL$ (r^2=0.54, n=11)

$\ln WtP = -2.38 + 2.99 \ln LHL$ (r^2=0.82, n=11)

7 Benefits and Conclusion

A key is provided which allows the identification of beaks of 75 speeies of cephalopod from southern Australia.

Formulae are provided to calculate cephalopod size and biomass based on measurements of their beaks. The principal application of this will be identification of gut contents of species which eat cephalopods.

A table provides details of the species examined, classified to order and family, with information on the size and weight range of whole animals.

Detailed descriptions of beaks are provided for each species, supplemented by further tables providing ranges, ratios and means of various beak characters.

8 Further Developments

Two further developments are possible, funding permitting. Collection and analysis of further cephalopod beak material would allow the formulae developed here to be further refined. A similar project with a scope that included the tropical cephalopod fauna of Australia would be valuable.

9 Planned Outcomes

This publication fully meets the planned outcomes of the project:

To produce a diagnostic illustrated key for identification of cephalopod beaks in the diets of marine vertebrates from southern Australian waters.

To analyse relationships between beak morphometrics and whole animal attributes, in order to develop back-calculation formulae for estimation of prey size and biomass.

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APPENDIX 1: Intellectual Property

General disclaimer

APPENDIX 2: Staff engaged and associated with this project

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APPENDIX 3: Additional calculated regressions for estimating size and weight of Sepioidea from upper beak dimensions.

Species	Equations for estimating mantle length (ML) in mm.		Equations for estimating fresh (WtF) or preserved (WtP) weight in g.	
Spirula spirula	ML = 6.40 + 5.56 UCL	(r^2=0.69, n=8)	n/s	
Sepia apama	ML = -8.40 + 7.00 UHL	(r^2=0.99, n=32)	ln WtF = -5.78 + 3.60 ln UHL	(r^2=0.91, n=7)
			ln WtP = -3.12 + 3.02 ln UHL	(r^2=0.99, n=24)
	ML = -10.21 + 5.41 UCL	(r^2=0.99, n=31)	ln WtF = -6.65 + 3.58 ln UCL	(r^2=0.95, n=7)
			ln WtP = -4.09 + 2.93 ln UCL	(r^2=0.99, n=23)
Sepia braggi	ML = -7.18 + 13.11 UHL	(r^2=0.91, n=21)	ln WtP = -2.49 + 3.16 ln UHL	(r^2=0.92, n=21)
	ML = -7.46 + 8.33 UCL	(r^2=0.93, n=21)	ln WtP = -3.95 + 3.16 ln UCL	(r^2=0.94, n=21)
Sepia chirotrema	ML = 12.97 + 7.59 UHL	(r^2=0.88, n=18)	ln WtP = -1.56 + 2.34 ln UHL	(r^2=0.87, n=18)
	ML = 4.30 + 5.52 UCL	(r^2=0.83, n=18)	ln WtP = -3.32 + 2.79 ln UCL	(r^2=0.84, n=18)
Sepia cultrata	ML = 9.09 + 8.89 UHL	(r^2=0.78, n=28)	ln WtP = -1.04 + 2.34 ln UHL	(r^2=0.81, n=27)
	ML = 9.95 + 5.69 UCL	(r^2=0.89, n=24)	ln WtP = -2.10 + 2.35 ln UCL	(r^2=0.89, n=23)
Sepia hedleyi	ML = 11.49 + 6.73 UHL	(r^2=0.86, n=30)	ln WtP = -1.96 + 2.55 ln UHL	(r^2=0.91, n=30)
	ML = 10.31 + 4.84 UCL	(r^2=0.89, n=32)	ln WtP = -2.73 + 2.51 ln UCL	(r^2=0.94, n=32)
Sepia irvingi	ML = -10.49 + 8.43 UHL	(r^2=0.96, n=9)	ln WtP = -2.74 + 2.91 ln UHL	(r^2=0.95, n=9)
	ML = -7.24 + 6.21 UCL	(r^2=0.97, n=7)	ln WtP = -3.77 + 2.98 ln UCL	(r^2=0.98, n=7)
Sepia mestus	ML = -1.06 + 6.61 UHL	(r^2=0.99, n=7)	ln WtP = -2.82 + 2.74 ln UHL	(r^2=0.99, n=7)
	ML = 2.27 + 4.62 UCL	(r^2=0.99, n=7)	ln WtP = -3.53 + 2.71 ln UCL	(r^2=0.99, n=7)
Sepia novaehollandiae	ML = 0.64 + 7.82 UHL	(r^2=0.94, n=21)	ln WtP = -3.07 + 3.03 ln UHL	(r^2=0.98, n=20)
	ML = 1.47 + 5.52 UCL	(r^2=0.93, n=)	ln WtP = -3.68 + 2.88 ln UCL	(r^2=0.95, n=25)
Sepia plangon	ML = 5.00 + 8.73 UHL	(r^2=0.87, n=28)	ln WtP = -2.04 + 2.71 ln UHL	(r^2=0.92, n=28)
	ML = 12.37 + 5.55 UCL	(r^2=0.85, n=30)	ln WtP = -2.19 + 2.37 ln UCL	(r^2=0.87, n=30)
Sepia rozella	ML = -17.95 + 9.65 UHL	(r^2=0.94, n=30)	ln WtP = -3.60 + 3.28 ln UHL	(r^2=0.96, n=30)
	ML = -9.79 + 6.44 UCL	(r^2=0.93, n=29)	ln WtP = -3.78 + 2.95 ln UCL	(r^2=0.94, n=29)
Sepiadarium austrinum	ML = -5.97 + 5.24 UCL	(r^2=0.68, n=9)	ln WtP = -3.53 + 2.84 ln UCL	(r^2=0.92, n=9)
Sepioloidea lineolata	ML = 3.60 + 3.07 UCL	(r^2=0.81, n=20)	ln WtP = -2.74 + 2.40 ln UCL	(r^2=0.96, n=20)
Rossia australis	ML = -4.87 + 4.97 UCL	(r^2=0.64, n=28)	ln WtP = -4.08 + 3.28 ln UCL	(r^2=0.81, n=28)
Heteroteuthis serventyi	ML = -5.24 + 4.57 UCL	(r^2=0.74, n=21)	ln WtP = -4.56 + 3.33 ln UCL	(r^2=0.80, n=21)
Iridoteuthis sp.	ML = -4.92 + 4.47 UCL	(r^2=0.66, n=15)	ln WtP = -3.86 + 3.08 ln UCL	(r^2=0.90, n=15)
Sepiolina nipponensis	n/s		ln WtP = -2.52 + 2.19 ln UCL	(r^2=0.54, n=9)
Euprymna tasmanica	ML = 12.49 + 2.10 UCL	(r^2=0.43, n=11)	ln WtP = -1.30 + 1.73 ln UCL	(r^2=0.66, n=11)

APPENDIX 4: Additional calculated regressions for estimating size and weight of Sepioidea from lower beak dimensions

Species	Equations for estimating mantle length (ML) in mm.		Equations for estimating fresh (WtF) or preserved (WtP) weight in g.	
Spirula spirula	n/s		n/s	
Sepia apama	ML = -0.26 + 17.06 LHL	(r^2=0.99, n=32)	ln WtF = -1.59 + 3.29 ln LHLln WtP = -0.01 + 2.72 ln LHL	(r^2=0.89, n=7)(r^2=0.98, n=24)
	ML = -8.41 + 7.37 LRF	(r^2=0.99, n=32)	ln WtF = -6.76 + 3.89 lnLRF	(r^2=0.96, n=7)
	ML = -6.70 + 8.47 LCL	(r^2=0.99, n=32)	ln WtF = -7.05 + 4.11 ln LCL	(r^2=0.94, n=7)
			ln WtP = -3.29 + 3.00 ln LRF	(r^2=0.99, n=24)
			ln WtP = -2.72 + 2.97 ln LCL	(r^2=0.99, n=24)
Sepia braggi	ML = -0.31 + 31.25 LHL	(r^2=0.84, n=20)	ln WtP = 0.93 + 2.55 ln LHL	(r^2=0.80, n=20)
	ML = -5.71 + 11.84 LRF	(r^2=0.92, n=21)	ln WtP = -2.55 + 3.05 ln LRF	(r^2=0.92, n=21)
	ML = -2.85 + 13.88 LCL	(r^2=0.89, n=21)	ln WtP = -1.68 + 2.87 ln LCL	(r^2=0.91, n=21)
Sepia chirotrema	ML = 34.55 + 15.84 LHL	(r^2=0.81, n=18)	ln WtP = 1.57 + 2.13 ln LHL	(r^2=0.78, n=18)
	ML = 1.32 + 8.12 LRF	(r^2=0.79, n=18)	ln WtP = -2.76 + 2.95 ln LRF	(r^2=0.86, n=18)
	ML = 9.85 + 9.27 LCL	(r^2=0.83, n=18)	ln WtP = -1.51 + 2.69 ln LCL	(r^2=0.95, n=18)
Sepia cultrata	ML = 5.19 + 23.17 LHL	(r^2=0.83, n=28)	ln WtP = 0.88 + 2.50 ln LHL	(r^2=0.86, n=27)
	ML = 7.28 + 8.44 LRF	(r^2=0.74, n=27)	ln WtP = -1.44 + 2.44 ln LRF	(r^2=0.80, n=26)
	ML = -1.78 + 11.70 LCL	(r^2=0.86, n=27)	ln WtP = -1.59 + 2.77 ln LCL	(r^2=0.88, n=26)
Sepia hedleyi	ML = 15.99 + 15.64 LHL	(r^2=0.83, n=33)	ln WtP = 0.79 + 2.25 ln LHL	(r^2=0.87, n=33)
	ML = 11.54 + 6.72 LRF	(r^2=0.85, n=33)	ln WtP = -1.78 + 2.47 ln LRF	(r^2=0.91, n=33)
	ML = 6.75 + 8.73 LCL	(r^2=0.89, n=33)	ln WtP = -1.62 + 2.62 ln LCL	(r^2=0.94, n=33)
Sepia irvingi	ML = -5.61 + 23.78 LHL	(r^2=0.80, n=9)	ln WtP = 0.11 + 3.07 ln LHL	(r^2=0.88, n=9)
	ML = -10.99 + 8.66 LRF	(r^2=0.97, n=9)	ln WtP = -3.00 + 3.03 ln LRF	(r^2=0.98, n=9)
	ML = -1.34 + 9.99 LCL	(r^2=0.92, n=9)	ln WtP = -2.14 + 2.95 ln LCL	(r^2=0.96, n=9)
Sepia mestus	ML = 7.09 + 16.05 LHL	(r^2=0.95, n=7)	ln WtP = 0.70 + 2.18 ln LHL	(r^2=0.96, n=7)
	ML = 0.76 + 7.01 LRF	(r^2=1.00, n=7)	ln WtP = -2.56 + 2.74 ln LRF	(r^2=0.99, n=7)
	ML = 1.63 + 8.15 LCL	(r^2=0.98, n=7)	ln WtP = -1.79 + 2.58 ln LCL	(r^2=0.99, n=7)
Sepia novaehollandiae	ML = 7.94 + 19.39 LHL	(r^2=0.90, n=27)	ln WtP = 0.44 + 2.70 ln LHL	(r^2=0.94, n=26)
	ML = -2.24 + 8.22 LRF	(r^2=0.92, n=)	ln WtP = -2.78 + 2.93 ln LRF	(r^2=0.96, n=26)
	ML = -3.02 + 10.88 LCL	(r^2=0.93, n=)	ln WtP = -2.52 + 3.07 ln LCL	(r^2=0.97, n=24)
Sepia plangon	ML = 21.17 + 16.53 LHL	(r^2=0.86, n=30)	ln WtP = 1.25 + 2.00 ln LHL	(r^2=0.88, n=30)
	ML = 11.09 + 8.11 LRF	(r^2=0.87, n=30)	ln WtP = -1.32 + 2.38 ln LRF	(r^2=0.91, n=30)
	ML = 7.59 + 10.03 LCL	(r^2=0.85, n=30)	ln WtP = -1.09 + 2.45 ln LCL	(r^2=0.87, n=30)
Sepia rozella	ML = -9.48 + 25.27 LHL	(r^2=0.91, n=30)	ln WtP = 0.32 + 2.91 ln LHL	(r^2=0.89, n=30)
	ML = -11.15 + 9.21 LRF	(r^2=0.94, n=30)	ln WtP = -2.94 + 3.03 ln LRF	(r^2=0.97, n=30)
	ML = -16.92 + 12.38 LCL	(r^2=0.95, n=30)	ln WtP = -2.60 + 3.21 ln LCL	(r^2=0.96, n=30)
Sepiadarium austrinum	ML = -0.51 + 5.68 LRF	(r^2=0.54, n=12)	ln WtP = -2.23 + 2.52 ln LRF	(r^2=0.80, n=12)
	ML = -1.13 + 7.12 LCL	(r^2=0.60, n=12)	ln WtP = -1.72 + 2.50 ln LCL	(r^2=0.81, n=12)
Sepioloidea lineolata	ML = 5.49 + 3.87 LRF	(r^2=0.76, n=20)	ln WtP = -1.70 + 2.25 ln LRF	(r^2=0.94, n=20)
	ML = 6.30 + 4.83 LCL	(r^2=0.77, n=20)	ln WtP = -0.86 + 2.06 ln LCL	(r^2=0.91, n=20)
Rossia australis	ML = -3.02 + 6.39 LRF	(r^2=0.70, n=30)	ln WtP = -2.65 + 3.04 ln LRF	(r^2=0.88, n=30)
	ML = 0.32 + 7.94 LCL	(r^2=0.67, n=28)	ln WtP = -1.39 + 2.82 ln LCL	(r^2=0.86, n=28)
Heteroteuthis serventyi	ML = -7.52 + 6.86 LRF	(r^2=0.80, n=24)	ln WtP = -3.59 + 3.38 ln LRF	(r^2=0.86, n=24)
	ML = -2.57 + 8.21 LCL	(r^2=0.78, n=24)	ln WtP = -1.69 + 2.78 ln LCL	(r^2=0.88, n=24)
Iridoteuthis sp.	ML = -0.21 + 5.09 LRF	(r^2=0.58, n=16)	ln WtP = -2.09 + 2.61 ln LRF	(r^2=0.83, n=16)
	ML = -2.55 + 7.20 LCL	(r^2=0.49, n=16)	ln WtP = -1.85 + 2.92 ln LCL	(r^2=0.80, n=16)
Sepiolina nipponensis	ML = 6.09 + 3.80 LRF	(r^2=0.39, n=11)	ln WtP = -2.04 + 2.41 ln LRF	(r^2=0.74, n=11)
	n/s		ln WtP = -1.38 + 2.33 ln LCL	(r^2=0.75, n=11)
Euprymna tasmanica	ML = 0.44 + 5.10 LRF	(r^2=0.83, n=15)	ln WtP = -2.91 + 3.00 ln LRF	(r^2=0.93, n=15)
	ML = 4.12 + 5.40 LCL	(r^2=0.91, n=13)	ln WtP = -1.55 + 2.49 ln LCL	(r^2=0.94, n=13)

APPENDIX 5: Additional calculated regressions for estimating size and weight of Teuthida from upper beak dimensions

Species	Equations for estimating mantle length (ML) in mm.		Equations for estimating fresh (WtF) or preserved (WtP) weight in g.	
Sepioteuthis australis	ML = -23.22 + 15.07 UHL	(r^2=0.89, n=37)	ln WtF = -2.32 + 2.96 ln UHL	(r^2=0.98, n=8)
	ML = -23.68 + 11.35 UCL	(r^2=0.92, n=36)	ln WtF = -3.06 + 2.91 ln UCL	(r^2=0.99, n=8)
			ln WtP = -2.09 + 2.77 ln UHL	(r^2=0.96, n=11)
			ln WtP = -2.87 + 2.78 ln UCL	(r^2=0.95, n=10)
Uroteuthis (Photololigo) noctiluca	ML = -4.07 + 11.41 UHL	(r^2=0.89, n=31)	ln WtP = -2.56 + 2.83 ln UHL	(r^2=0.86, n=31)
	ML = -2.97 + 8.22 UCL	(r^2=0.86, n=17)	ln WtP = -3.40 + 2.81 ln UCL	(r^2=0.86, n=17)
Lycoteuthis lorigera	ML = -20.71 + 13.71 UHL	(r^2=0.97, n=46)	ln WtP = -3.39 + 3.35 ln UHL	(r^2=0.98, n=46)
	ML = -22.22 + 9.41 UCL	(r^2=0.96, n=45)	ln WtP = -4.64 + 3.32 ln UCL	(r^2=0.97, n=45)
Enoploteuthis galaxias	ML = -42.77 + 14.42 UHL	(r^2=0.94, n=33)	ln WtP = -4.58 + 3.54 ln UHL	(r^2=0.95, n=33)
	ML = -32.95 + 9.57 UCL	(r^2=0.95, n=33)	ln WtP = -5.17 + 3.32 ln UCL	(r^2=0.97, n=33)
Enoploteuthis sp.	ML = -45.35 + 14.51 UHL	(r^2=0.64, n=14)	ln WtP = -5.68 + 3.96 ln UHL	(r^2=0.84, n=13)
	ML = -14.63 + 8.27 UCL	(r^2=0.60, n=14)	ln WtP = -5.51 + 3.41 ln UCL	(r^2=0.97, n=13)
Abraliopsis gilchristi	ML = -8.39 + 12.96 UHL	(r^2=0.79, n=28)	ln WtP = -3.13 + 3.26 ln UHL	(r^2=0.80, n=28)
	ML = -5.92 + 8.16 UCL	(r^2=0.81, n=28)	ln WtP = -4.20 + 3.11 ln UCL	(r^2=0.85, n=28)
Abraliopsis tui	ML = 0.20 + 8.81 UHL	(r^2=0.85, n=12)	ln WtP = -2.81 + 2.79 ln UHL	(r^2=0.87, n=12)
	ML = 0.21 + 6.27 UCL	(r^2=0.84, n=12)	ln WtP = -3.69 + 2.74 ln UCL	(r^2=0.84, n=12)
Pyroteuthis margaritifera	ML = 0.25 + 11.59 UHL	(r^2=0.88, n=24)	ln WtP = -2.30 + 3.23 ln UHL	(r^2=0.91, n=24)
	ML = 2.0 + 7.50 UCL	(r^2=0.91, n=25)	ln WtP = -3.27 + 3.05 ln UCL	(r^2=0.91, n=25)
Pterygioteuthis gemmata	ML = -0.68 + 13.55 UHL	(r^2=0.76, n=16)	ln WtP = -2.81 + 3.52 ln UHL	(r^2=0.80, n=16)
	ML = 1.77 + 8.73 UCL	(r^2=0.56, n=16)	ln WtP = -3.26 + 2.80 ln UCL	(r^2=0.77, n=16)
Ancistrocheirus lesueuri	ML = -15.68 + 10.65 UHL	(r^2=0.89, n=6)	ln WtP = -4.20 + 3.48 ln UHL	(r^2=0.96, n=5)
	ML = -19.47 + 7.80 UCL	(r^2=0.93, n=6)	ln WtP = -5.23 + 3.44 ln UCL	(r^2=0.97, n=5)
Octopoteuthis sp.	ML = -7.14 + 8.15 UHL	(r^2=0.96, n=18)	ln WtF = -1.48 + 2.41 ln UHL	(r^2=0.83, n=9)
	ML = -5.33 + 6.38 UCL	(r^2=0.97, n=18)	ln WtF = -1.62 + 2.28 ln UCL	(r^2=0.81, n=9)
			ln WtP = -4.10 + 3.11 ln UHL	(r^2=0.95, n=13)
			ln WtP = -5.05 + 3.20 ln UCL	(r^2=0.96, n=13)
Onychoteuthis banksii	ML = -17.40 + 14.79 UHL	(r^2=0.87, n=11)	ln WtP = -4.47 + 3.64 ln UHL	(r^2=0.97, n=11)
	ML = -34.57 + 13.15 UCL	(r^2=0.83, n=7)	ln WtP = -5.14 + 3.43 ln UCL	(r^2=0.92, n=7)
Ancistroteuthis sp.	ML = -52.67 + 21.64 UHL	(r^2=0.91, n=20)	ln WtP = -4.35 + 3.62 ln UHL	(r^2=0.94, n=19)
	ML = -39.65 + 13.90 UCL	(r^2=0.92, n=20)	ln WtP = -4.28 + 3.26 ln UCL	(r^2=0.90, n=19)
Moroteuthis ingens	ML = -248.25 + 22.67 UHL	(r^2=0.83, n=14)	ln WtF = -11.15 + 5.55 ln UHL	(r^2=0.90, n=12)
	ML = -303.59 + 18.32 UCL	(r^2=0.88, n=14)	ln WtF = -14.20 + 5.94 ln UCL	(r^2=0.92, n=12)
Moroteuthis robsoni	ML = 63.40 + 17.87 UHL	(r2=0.54, n=8)	ln WtF = -3.40 + 3.35 ln UHL	(r^2=0.65, n=7)
	ML = -203.24 + 20.81 UCL	(r2=0.73, n=7)	ln WtF = -9.15 + 4.66 ln UCL	(r^2=0.82, n=6)
Pholidoteuthis boschmai	ML = -33.56 + 16.58 UHL	(r^2=0.99, n=8)	ln WtF = -6.11 + 4.08 ln UHL	(r^2=0.96, n=4)
	ML = -21.68 + 10.99 UCL	(r^2=1.00, n=7)	ln WtF = -5.84 + 3.60 ln UCL	(r^2=0.98, n=4)
			ln WtP = -2.75 + 2.73 ln UHL	(r^2=0.96, n=4)
			ln WtP = -4.04 + 2.91 ln UCL	(r^2=0.98, n=3)
Architeuthis sp.	ML = -222.21 + 25.50 UHL	(r^2=0.83, n=5)	ln WtF = -24.86 + 8.38 ln UHL	(r^2=0.89, n=3)
	ML = -165.63 + 17.47 UCL	(r^2=0.82, n=5)	ln WtF = -18.90 + 6.50 ln UCL	(r^2=0.54, n=3)
Histioteuthis atlantica	ML = -10.73 + 8.66 UHL	(r^2=0.92, n=26)	ln WtP = -1.73 + 2.64 ln UHL	(r^2=0.96, n=24)
	ML = -11.57 + 6.41 UCL	(r^2=0.93, n=26)	ln WtP = -2.60 + 2.66 ln UCL	(r^2=0.96, n=24)
Histioteuthis bonnelli corpuscula	ML = -4.46 + 5.73 UHL	(r^2=0.95, n=21)	ln WtP = -2.99 + 3.21 ln UHL	(r^2=0.93, n=21)
	ML = -2.80 + 4.20 UCL	(r^2=0.95, n=19)	ln WtP = -3.75 + 3.16 ln UCL	(r^2=0.93, n=19)
Histioteuthis eltaninae	ML = -3.20 + 7.32 UHL	(r^2=1.00, n=6)	ln WtP = -3.74 + 3.38 ln UHL	(r^2=0.97, n=5)

APPENDIX 5: (cont.)

	ML = -2.43 + 5.49 UCL	(r^2=0.99, n=6)	ln WtP = -4.52 + 3.33 ln UCL	(r^2=0.98, n=5)
Histioteuthis macrohista	ML = -5.69 + 6.42 UHL	(r^2=0.96, n=8)	ln WtP = -3.12 + 3.49 ln UHL	(r^2=0.97, n=8)
	ML = -5.19 + 4.67 UCL	(r^2=0.98, n=8)	ln WtP = -4.03 + 3.41 ln UCL	(r^2=0.98, n=8)
Histioteuthis miranda	ML = -43.66 + 11.51 UHL	(r^2=0.90, n=31)	ln WtF = -3.65 + 3.37 ln UHL	(r^2=0.96, n=22)
	ML = -44.16 + 9.37 UCL	(r^2=0.92, n=31)	ln WtF = -4.33 + 3.56 ln UCL	(r^2=0.97, n=22)
Histioteuthis reversa	ML = -1.27 + 7.64 UHL	(r^2=0.92, n=12)	ln WtP = -2.32 + 2.90 ln UHL	(r^2=0.93, n=12)
	ML = -1.78 + 5.76 UCL	(r^2=0.93, n=12)	ln WtP = -3.43 + 3.03 ln UCL	(r^2=0.95, n=12)
Bathyteuthis abyssicola	ML = -6.03 + 17.44 UHL	(r^2=0.77, n=12)	ln WtP = -0.73 + 2.57 ln UHL	(r^2=0.78, n=12)
	ML = -2.73 + 9.42 UCL	(r^2=0.82, n=12)	ln WtP = -1.94 + 2.45 ln UCL	(r^2=0.80, n=12)
Ctenopteryx siculus	ML = -1.84 + 13.27 UHL	(r^2=0.79, n=13)	ln WtP = -2.57 + 3.28 ln UHL	(r^2=0.83, n=13)
	ML = -6.41 + 9.54 UCL	(r^2=0.86, n=13)	ln WtP = -4.17 + 3.41 ln UCL	(r^2=0.89, n=13)
Brachioteuthis cf. *Riisei*	ML = 5.85 + 10.74 UHL	(r^2=0.95, n=22)	ln WtP = -3.28 + 3.00 ln UHL	(r^2=0.95, n=22)
	ML = 11.05 + 6.05 UCL	(r^2=0.93, n=19)	ln WtP = -4.21 + 2.78 ln UCL	(r^2=0.97, n=19)
Todaropsis eblane	ML = -32.62 + 10.12 UHL	(r^2=0.91, n=29)	ln WtP = -3.17 + 2.86 ln UHL	(r^2=0.96, n=25)
	ML = -36.74 + 8.16 UCL	(r^2=0.88, n=28)	ln WtP = -4.02 +2.90 ln UCL	(r^2=0.97, n=24)
Todarodes filippovae	ML = 10.78 + 12.52 UHL	(r^2=0.95, n=97)	ln WtF = -3.36 + 3.06 ln UHL	(r^2=0.87, n=86)
	ML = 22.73 + 9.64 UCL	(r^2=0.95, n=100)	ln WtF = -3.64 + 2.95 ln UCL	(r^2=0.87, n=88)
Nototodarus gouldi	ML = 16.53 + 11.52 UHL	(r^2=0.92, n=92)	ln WtF = -3.52 + 3.16 ln UHL	(r^2=0.95, n=66)
	ML = 19.13 + 9.04 UCL	(r^2=0.94, n=93)	ln WtF = -4.26 + 3.16 ln UCL	(r^2=0.96, n=67)
Ommastrephes bartrami	ML = 6.91 + 11.78 UHL	(r^2=0.97, n=28)	ln WtF = -1.58 + 2.56 ln UHL	(r^2=0.98, n=5)
	ML = 7.97 + 9.66 UCL	(r^2=0.97, n=29)	ln WtF = -2.25 + 2.62 ln UCL	(r^2=0.99, n=5)
			ln WtP = -2.80 + 2.94 ln UHL	(r^2=0.99, n=23)
			ln WtP = -3.38 + 2.95 ln UCL	(r^2=0.99, n=24)
Eucleoteuthis luminosa	ML = 2.41 + 11.94 UHL	(r^2=0.97, n=25)	ln WtP = -2.42 + 2.57 ln UHL	(r^2=0.97, n=25)
	ML = 4.69 + 9.57 UCL	(r^2=0.97, n=25)	ln WtP = -2.95 + 2.59 ln UCL	(r^2=0.98, n=25)
Ornithoteuthis volatilis	ML = -15.07 + 12.95 UHL	(r^2=0.96, n=39)	ln WtP = -2.99 + 2.76 ln UHL	(r^2=0.98, n=40)
	ML = -14.14 + 10.39 UCL	(r^2=0.96, n=39)	ln WtP = -3.54 + 2.74 ln UCL	(r^2=0.98, n=40)
Mastigoteuthis cordiformis	n/s		ln WtF = -9.00 + 4.71 ln UHL	(r^2=0.98, n=5)
	n/s		ln WtF = -12.05 + 5.07 ln UCL	(r^2=0.99, n=5)
Cranchia scabra	ML = 35.21 + 10.52 UHL	(r^2=0.86, n=17)	ln WtP = -0.45 + 1.93 ln UHL	(r^2=0.94, n=16)
	ML = 26.67 + 8.36 UCL	(r^2=0.96, n=9)	ln WtP = -1.17 + 1.94 ln UCL	(r^2=0.97, n=8)
Liocranchia reinhardti	ML = 15.75 + 17.38 UHL	(r^2=0.71, n=26)	ln WtP = -2.45 + 2.90 ln UHL	(r^2=0.92, n=26)
	ML = 15.76 + 12.65 UCL	(r^2=0.68, n=24)	ln WtP = -3.65 + 3.07 ln UCL	(r^2=0.94, n=24)
Megalocranchia abyssicola	ML = -31.78 + 16.87 UHL	(r^2=0.79, n=9)	ln WtP = -3.72 + 2.80 ln UHL	(r^2=0.98, n=9)
	ML = -42.82 + 15.37 UCL	(r^2=0.79, n=8)	ln WtP = -4.36 + 2.90 ln UCL	(r^2=0.99, n=8)
Sandalops melancholicus	ML = 2.08 + 16.75 UHL	(r^2=0.86, n=9)	ln WtP = -2.27 + 2.92 ln UHL	(r^2=0.91, n=9)
	ML = -0.13 + 11.61 UCL	(r^2=0.87, n=9)	ln WtP = -3.70 + 3.07 ln UCL	(r^2=0.93, n=9)
Teuthowenia pellucida	ML = 16.49 + 10.63 UHL	(r^2=0.85, n=40)	ln WtP = -1.96 + 2.19 ln UHL	(r^2=0.96, n=40)
	ML = 14.36 + 8.34 UCL	(r^2=0.87, n=34)	ln WtP = -2.82 + 2.32 ln UCL	(r^2=0.98, n=34)

APPENDIX 6: Additional calculated regressions for estimating size and weight of Teuthida from lower beak dimensions

Species	Equations for estimating mantle length (ML) in mm.		Equations for estimating fresh (WtF) or preserved (WtP) weight in g.	
Sepioteuthis australis	ML = -29.68 + 16.64 LRF	(r^2=0.91, n=36)	ln WtF = -1.76 + 2.81 ln LRF	(r^2=0.99, n=8)
	ML = -8.71 + 40.21 LHL	(r^2=0.77, n=36)	ln WtF = 0.14 + 3.41 ln LHL	(r^2=0.97, n=7)
	ML = -19.92 + 18.18 LCL	(r^2=0.89, n=36)	ln WtF = -0.66 + 2.49 ln LCL	(r^2=0.97, n=8)
			ln WtP = -2.23 + 2.89 ln LRF	(r^2=0.97, n=10)
			ln WtP = 1.17 + 2.53 ln LHL	(r^2=0.96, n=11)
			ln WtP = -1.45 + 2.73 ln LCL	(r^2=0.96, n=10)
Uroteuthis (Photololigo) noctiluca	ML = -3.67 + 11.46 LRF	(r^2=0.90, n=26)	ln WtP = -2.49 + 2.79 ln LRF	(r^2=0.87, n=26)
	ML = 2.85 + 25.90 LHL	(r^2=0.82, n=26)	ln WtP = 0.35 + 2.46 ln LHL	(r^2=0.81, n-26)
	ML = -3.51 + 14.46 LCL	(r^2=0.85, n=22)	ln WtP = -1.92 + 2.85 ln LCL	(r^2=0.81, n=22)
Lycoteuthis lorigera	ML = -25.17 + 13.13 LRF	(r^2=0.97, n=42)	ln WtP = -3.63 + 3.32 ln LRF	(r^2=0.98, n=42)
	ML = -10.65 + 32.01 LHL	(r^2=0.95, n=46)	ln WtP = 0.29 + 2.88 ln LHL	(r^2=0.95, n=46)
	ML = -22.93 + 21.69 LCL	(r^2=0.95, n=39)	ln WtP = -1.72 + 3.21 ln LCL	(r^2=0.97, n=39)
Enoploteuthis galaxias	ML = -28.15 + 12.32 LRF	(r^2=0.95, n=33)	ln WtP = -3.64 + 3.07 ln LRF	(r^2=0.95, n=33)
	ML = -9.34 + 27.40 LHL	(r^2=0.92, n=33)	ln WtP = -0.03 + 2.59 ln LHL	(r^2=0.94, n=33)
	ML = -22.09 + 19.25 LCL	(r^2=0.89, n=33)	ln WtP = -2.01 + 3.02 ln LCL	(r^2=0.92, n=33)
Enoploteuthis sp.	ML = -23.42 + 11.54 LRF	(r^2=0.62, n=13)	ln WtP = -5.43 + 3.75 ln LRF	(r^2=0.95, n=12)
	ML = -7.68 + 26.58 LHL	(r^2=0.66, n=13)	ln WtP = -0.69 + 2.98 ln LHL	(r^2=0.85, n=12)
	n/s		n/s	
Abraliopsis gilchristi	ML = -4.87 + 10.73 LRF	(r^2=0.78, n=27)	ln WtP = -3.25 + 3.09 ln LRF	(r^2=0.84, n=27)
	ML = 7.42 + 20.12 LHL	(r^2=0.64, n=27)	ln WtP = 0.10 + 2.26 ln LHL	(r^2=0.76, n=27)
	ML = -1.17 + 15.21 LCL	(r^2=0.73, n=27)	ln WtP = -1.64 + 2.83 ln LCL	(r^2=0.82, n=27)
Abraliopsis tui	ML = 3.36 + 7.45 LRF	(r^2=0.83, n=12)	ln WtP = -2.58 + 2.49 ln LRF	(r^2=0.86, n=12)
	ML = 4.68 + 18.92 LHL	(r^2=0.75, n=11)	ln WtP = -0.08 + 2.32 ln LHL	(r^2=0.77, n=11)
	ML = 3.52 + 11.56 LCL	(r^2=0.73, n=11)	ln WtP = -1.47 + 2.50 ln LCL	(r^2=0.79, n=11)
Pyroteuthis margaritifera	ML = 2.58 + 10.02 LRF	(r^2=0.90, n=25)	ln WtP = -2.22 + 2.96 ln LRF	(r^2=0.91, n=25)
	ML = 5.48 + 21.54 LHL	(r^2=0.81, n=25)	ln WtP = 0.41 + 2.78 ln LHL	(r^2=0.88, n=25)
	ML = 2.13 + 14.44 LCL	(r^2=0.86, n=25)	ln WtP = -1.24 + 3.04 ln LCL	(r^2=0.88, n=25)
Pterygioteuthis gemmata	ML = -3.78 + 14.86 LRF	(r^2=0.81, n=19)	ln WtP = -2.99 + 3.70 ln LRF	(r^2=0.86, n=19)
	ML = 2.32 + 27.87 LHL	(r^2=0.63, n=18)	ln WtP = 0.09 + 3.18 ln LHL	(r^2=0.79, n=18)
	ML = 0.68 + 16.74 LCL	(r^2=0.72, n=19)	ln WtP = -1.75 + 3.21 ln LCL	(r^2=0.89, n=19)
Ancistrocheirus lesueuri	ML = -20.49 + 11.07 LRF	(r^2=0.90, n=6)	ln WtP = -4.32 + 3.52 ln LRF	(r^2=0.98, n=5)
	ML = -49.77 + 54.23 LHL	(r^2=0.95, n=6)	ln WtP = -0.23 + 4.27 ln LHL	(r^2=0.97, n=5)
	ML = -26.09 + 20.16 LCL	(r^2=0.96, n=6)	ln WtP = -2.27 + 3.53 ln LCL	(r^2=0.95, n=5)
Octopoteuthis sp.	ML = -2.48 + 8.30 LRF	(r^2=0.97, n=18)	ln WtF = -1.46 + 2.43 ln LRF	(r^2=0.86, n=9)
	ML = -14.14 + 32.62 LHL	(r^2=0.94, n=18)	ln WtF = 1.99 + 2.27 ln LHL	(r^2=0.66, n=9)
	ML = -7.23 + 15.37 LCL	(r^2=0.97, n=18)	ln WtF = -0.45 + 2.60 ln LCL	(r^2=0.91, n=9)
			ln WtP = -3.63 + 3.02 ln LRF	(r^2=0.97, n=13)
			ln WtP = 0.12 + 3.04 ln LHL	(r^2=0.93, n=13)
			ln WtP = -1.77 + 2.95 ln LCL	(r^2=0.96, n=13)
Onychoteuthis banksii	ML = -5.26 + 12.53 LRF	(r^2=0.85, n=10)	ln WtP = -3.87 + 3.27 ln LRF	(r^2=0.95, n=10)
	ML = 7.73 + 38.45 LHL	(r^2=0.71, n=8)	ln WtP = 0.8 + 2.46 ln LHL	(r^2=0.80, n=8)
	ML = -1.24 + 17.59 LCL	(r^2=0.86, n=10)	ln WtP = -2.27 + 3.06 ln LCL	(r^2=0.96, n=10)
Ancistroteuthis sp.	ML = -38.46 + 18.56 LRF	(r^2=0.91, n=19)	ln WtP = -3.65 + 3.19 ln LRF	(r^2=0.90, n=18)
	ML = -31.20 + 60.53 LHL	(r^2=0.87, n=19)	ln WtP = 0.54 + 2.70 ln LHL	(r^2=0.78, n=18)
	ML = -37.34 + 30.08 LCL	(r^2=0.97, n=18)	ln WtP = -2.43 + 3.52 ln LCL	(r^2=0.91, n=17)
Moroteuthis ingens	ML = -336.02 + 24.77 LRF	(r^2=0.81, n=14)	ln WtF = -13.38 + 6.15 ln LRF	(r^2=0.86, n=12)

APPENDIX 6: (cont).

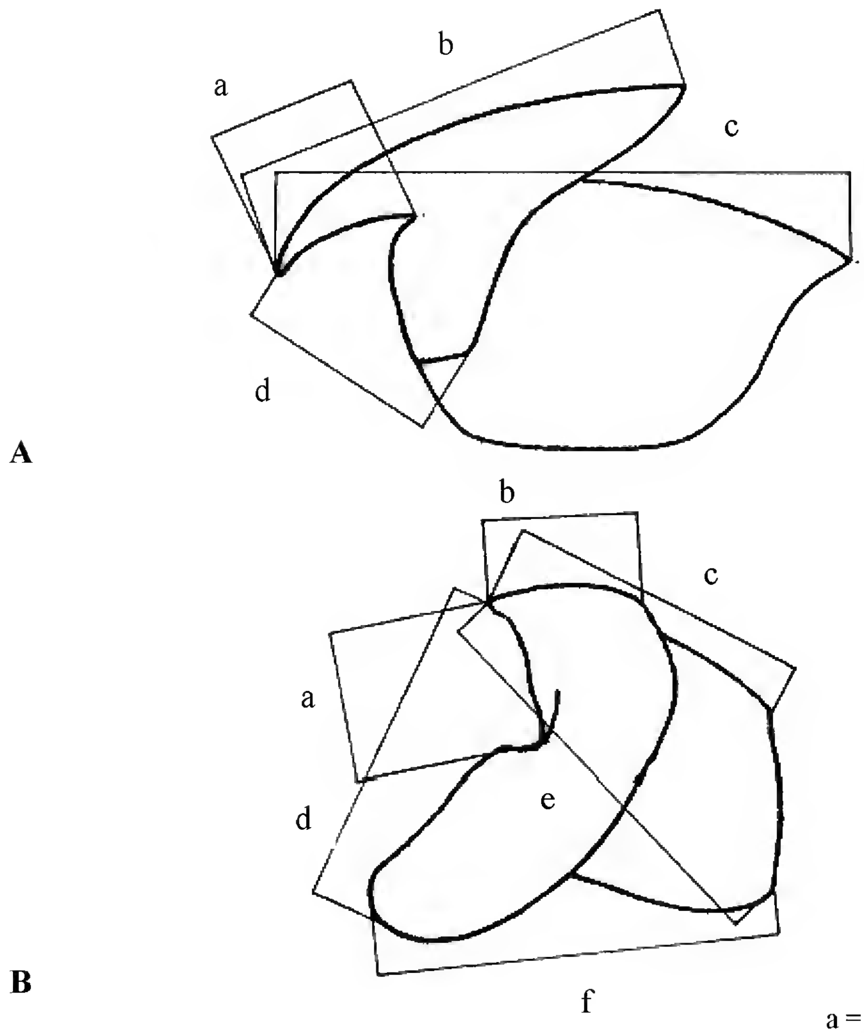
	n/s		n/s	
	ML = -413.44 + 32.47 LCL	(r^2=0.83, n=12)	ln WtF = -12.49 + 6.22 ln LCL	(r^2=0.86, n=10)
Moroteuthis robsoni	ML = -113.16 + 25.36 LRF	(r^2=0.70, n=8)	ln WtF = -6.75 + 4.40 ln LRF	(r^2=0.80, n=6)
	ML = -439.92 + 122.99 LHL	(r^2=0.80, n=8)	ln WtF = -4.83 + 5.96 ln LHL	(r^2=0.78, n=6)
	ML = -60.29 + 33.83 LCL	(r^2=0.90, n=6)	ln WtF = -5.16 + 4.42 ln LCL	(r^2=0.98, n=4)
Pholidoteuthis boschmai	ML = -30.16 + 14.75 LRF	(r^2=0.99, n=7)	ln WtF = -5.71 + 3.84 ln LRF	(r^2=0.96, n=4)
	ML = -23.11 + 39.60 LHL	(r^2=0.98, n=7)	ln WtF = -1.84 + 3.83 ln LHL	(r^2=0.95, n=4)
	ML = -5.51 + 18.80 LCL	(r^2=0.99, n=7)	ln WtF = -2.10 + 3.08 ln LCL	(r^2=0.94, n=4)
			ln WtP = -3.17 + 2.87 ln LRF	(r^2=0.99, n=3)
			ln WtP = 0.31 + 2.41 ln LHL	(r^2=0.97, n=3)
			ln WtP = -2.40 + 3.33 ln LCL	(r^2=0.98, n=3)
Architeuthis sp.	ML = -59.62 + 20.95 LRF	(r^2=0.98, n=4)	ln WtF = 0.98 + 2.48 ln LRF	(r^2=1.00, n=2)
	n/s		n/s	
	ML = -23.38 + 29.16 LCL	(r^2=0.94, n=4)	ln WtF = 9.46 + 0.61 ln LCL	(r^2=1.00, r=2)
Histioteuthis atlantica	ML = -10.01 + 8.73 LRF	(r^2=0.92, n=26)	ln WtP = -1.55 + 2.58 ln LRF	(r^2=0.95, n=24)
	ML = -6.74 + 19.83 LHL	(r^2=0.93, n=26)	ln WtP = 0.82 + 2.49 ln LHL	(r^2=0.95, n=24)
	ML = -12.19 + 13.81 LCL	(r^2=0.92, n=26)	ln WtP = -0.57 + 2.65 ln LCL	(r^2=0.95, n=24)
Histioteuthis bonnelli copuscula	ML = -2.36 + 5.36 LRF	(r^2=0.94, n=21)	ln WtP = -2.69 + 3.04 ln LRF	(r^2=0.93, n=21)
	ML = -4.23 + 15.73 LHL	(r^2=0.92, n=21)	ln WtP = 0.35 + 3.11 ln LHL	(r^2=0.91, n=21)
	ML = -1.06 + 8.12 LCL	(r^2=0.93, n=21)	ln WtP = -1.80 + 2.97 ln LCL	(r^2=0.90, n=21)
Histioteuthis eltaninae	ML = -4.27 + 7.81 LRF	(r^2=1.00, n=5)	ln WtP = -3.46 + 3.36 ln LRF	(r^2=0.98, n=4)
	ML = -1.30 + 18.48 LHL	(r^2=0.99, n=5)	ln WtP = -0.22 + 3.51 ln LHL	(r^2=0.87, n=4)
	ML = -4.07 + 12.06 LCL	(r^2=1.00, n=6)	ln WtP = -2.26 + 3.52 ln LCL	(r^2=0.99, n=5)
Histioteuthis macrohista	ML = -5.24 + 6.47 LRF	(r^2=0.98, n=8)	ln WtP = -2.97 + 3.44 ln LRF	(r^2=0.99, n=8)
	ML = -2.42 + 14.81 LHL	(r^2=0.96, n=8)	ln WtP = 0.36 + 3.23 ln LHL	(r^2=0.98, n=8)
	ML = -10.17 + 11.80 LCL	(r^2=0.99, n=8)	ln WtP = -1.88 + 3.85 ln LCL	(r^2=0.97, n=8)
Histioteuthis miranda	ML = -46.97 + 12.98 LRF	(r^2=0.93, n=31)	ln WtF = -3.28 + 3.35 ln LRF	(r^2=0.97, n=22)
	ML = -48.73 + 36.81 LHL	(r^2=0.85, n=30)	ln WtF = -0.38 + 3.65 ln LHL	(r^2=0.94, n=21)
	ML = -44.68 + 20.00 LCL	(r^2=0.91, n=31)	ln WtF = -2.00 + 3.42 ln LCL	(r^2=0.96, n=22)
Histioteuthis reversa	ML = -1.97 + 7.75 LRF	(r^2=0.93, n=12)	ln WtP = -2.49 + 2.99 ln LRF	(r^2=0.91, n=12)
	ML = 5.55 + 17.03 LHL	(r^2=0.92, n=12)	ln WtP = 1.01 + 2.22 ln LHL	(r^2=0.80, n=12)
	ML = -1.89 + 11.63 LCL	(r^2=0.96, n=12)	ln WtP = -1.14 + 2.90 ln LCL	(r^2=0.95, n=12)
Bathyteuthis abyssicola	ML = 5.30 + 12.36 LRF	(r^2=0.77, n=12)	ln WtP = -0.28 + 1.99 ln LRF	(r^2=0.73, n=12)
	ML = 6.69 + 23.15 LHL	(r^2=0.66, n=12)	ln WtP = 1.07 + 1.91 ln LHL	(r^2=0.70, n=12)
	ML = 5.96 + 16.29 LCL	(r^2=0.75, n=12)	ln WtP = 0.31 + 1.99 ln LCL	(r^2=0.76, n=12)
Ctenopteryx siculus	ML = -5.26 + 14.00 LRF	(r^2=0.91, n=13)	ln WtP = -2.66 + 3.32 ln LRF	(r^2=0.93, n=13)
	ML = -3.46 + 32.32 LHL	(r^2=0.92, n=12)	ln WtP = 0.29 + 3.16 ln LHL	(r^2=0.93, n=12)
	ML = 0.86 + 17.11 LCL	(r^2=0.90, n=13)	ln WtP = -1.27 + 3.01 ln LCL	(r^2=0.91, n=13)
Brachioteuthis cf. *riisei*	ML = 6.25 + 8.13 LRF	(r^2=0.94, n=25)	ln WtP = -3.86 + 2.89 ln LRF	(r^2=0.94, n=25)
	ML = 3.11 + 24.78 LHL	(r^2=0.83, n=23)	ln WtP = -1.06 + 3.16 ln LHL	(r^2=0.86, n=23)
	ML = 11.76 + 11.20 LCL	(r^2=0.93, n=22)	ln WtP = -2.44 + 2.76 ln LCL	(r^2=0.94, n=22)
Mastigoteuthis cordiformis	n/s		ln WtF = -10.75 + 5.08 ln LRF	(r^2=0.99, n=5)
	n/s		ln WtF = -2.38 + 3.84 ln LHL	(r^2=0.99, n=4)
	n/s		ln WtF = -8.49 + 4.92 ln LCL	(r^2=0.99, n=5)
Todaropsis eblane	ML = -36.40 + 11.88 LRF	(r^2=0.88, n=28)	ln WtP = -3.03 + 2.96 ln LRF	(r^2=0.94, n=24)
	ML = -35.56 + 31.63 LHL	(r^2=0.82, n=28)	ln WtP = -0.19 + 3.00 ln LHL	(r^2=0.97, n=24)
	ML = -39.01 + 16.83 LCL	(r^2=0.77, n=26)	ln WtP = -1.82 + 2.82 ln LCL	(r^2=0.90, n=22)

APPENDIX 6: (cont.)

Todarodes filippovae	ML = 3.14 + 14.28 LRF	(r^2=0.96, n=99)	ln WtF = -3.24 + 3.13 ln LRF	(r^2=0.88, n=87)
	ML = -2.99 + 40.78 LHL	(r^2=0.79, n=56)	ln WtF = -0.57 + 3.36 ln LHL	(r^2=0.73, n=54)
	ML = -11.42 + 21.47 LCL	(r^2=0.93, n=49)	ln WtF = -1.81 + 3.06 ln LCL	(r^2=0.86, n=48)
Nototodarus gouldi	ML = 25.26 + 12.25 LRF	(r^2=0.93, n=91)	ln WtF = -2.99 + 3.08 ln LRF	(r^2=0.97, n=67)
	ML = 41.12 + 32.31 LHL	(r^2=0.89, n=91)	ln WtF = 0.63 + 2.86 ln LHL	(r^2=0.88, n=67)
	ML = 42.85 + 16.57 LCL	(r^2=0.90, n=90)	ln WtF = -0.91 + 2.74 ln LCL	(r^2=0.95, n=66)
Ommastrephes bartrami	ML = 10.34 + 13.22 LRF	(r^2=0.97, n=29)	ln WtF = -0.92 + 2.46 ln LRF	(r^2=1.00, n=5)
	ML = 9.49 + 32.51 LHL	(r^2=0.95, n=29)	ln WtF = 1.01 + 2.55 ln LHL	(r^2=0.97, n=5)
	ML = 15.82 + 16.82 LCL	(r^2=0.96, n=29)	ln WtF = -0.81 + 2.70 ln LCL	(r^2=0.98, n=5)
			ln WtP = -2.28 + 2.89 ln LRF	(r^2=0.99, n=24)
			ln WtP = 0.14 + 2.99 ln LHL	(r^2=0.99, n=24)
			ln WtP = -1.36 + 2.83 ln LCL	(r^2=0.99, n=24)
Eucleoteuthis luminosa	ML = 4.14 + 12.97 LRF	(r^2=0.95, n=25)	ln WtP = -2.14 + 2.57 ln LRF	(r^2=0.97, n=25)
	ML = -4.26 + 37.71 LHL	(r^2=0.93, n=25)	ln WtP = 0.20 + 2.72 ln LHL	(r^2=0.96, n=25)
	ML = 6.43 + 17.53 LCL	(r^2=0.98, n=25)	ln WtP = -1.07 + 2.42 ln LCL	(r^2=0.98, n=25)
Ornithoteuthis volatilis	ML = -10.57 + 13.76 LRF	(r^2=0.95, n=39)	ln WtP = -2.50 + 2.66 ln LRF	(r^2=0.98, n=40)
	ML = -20.99 + 44.30 LHL	(r^2=0.94, n=39)	ln WtP = 0.10 + 2.91 ln LHL	(r^2=0.96, n=40)
	ML = -10.54 + 23.50 LCL	(r^2=0.93, n=38)	ln WtP = -1.06 + 2.64 ln LCL	(r^2=0.97, n=39)
Cranchia scabra	ML = 34.75 + 10.57 LRF	(r^2=0.88, n=16)	ln WtP = -0.23 + 1.79 ln LRF	(r^2=0.90, n=15)
	ML = 42.83 + 20.69 LHL	(r^2=0.87, n=15)	ln WtP = 1.31 + 1.73 ln LHL	(r^2=0.93, n=14)
	ML = 36.72 + 12.92 LCL	(r^2=0.83, n=12)	ln WtP = 0.11 + 1.83 ln LCL	(r^2=0.90, n=11)
Liocranchia reinhardti	ML = 17.39 + 16.91 LRF	(r^2=0.67, n=27)	ln WtP = -2.52 + 2.96 ln LRF	(r^2=0.94, n=27)
	ML = 25.73 + 40.33 LHL	(r^2=0.61, n=27)	ln WtP = 0.42 + 2.92 ln LHL	(r^2=0.94, n=27)
	ML = 17.24 + 22.41 LCL	(r^2=0.69, n=27)	ln WtP = -1.63 + 2.91 ln LCL	(r^2=0.94, n=27)
Megalochranchia abyssicola	ML = -35.69 + 18.97 LRF	(r^2=0.79, n=9)	ln WtP = -3.70 + 2.90 ln LRF	(r^2=0.99, n=9)
	ML = -45.06 + 69.53 LHL	(r^2=0.66, n=9)	ln WtP = -0.18 + 2.94 ln LHL	(r^2=0.94, n=9)
	ML = -41.56 + 30.13 UCL	(r^2=0.78, n=9)	ln WtP = -2.50 + 2.93 ln LCL	(r^2=0.98, n=9)
Sandalops melancholicus	ML = 6.96 + 13.46 LRF	(r^2=0.85, n=9)	ln WtP = -2.34 + 2.70 ln LRF	(r^2=0.91, n=9)
	ML = 5.74 + 37.69 LHL	(r^2=0.83, n=9)	ln WtP = -0.33 + 2.81 ln LHL	(r^2=0.91, n=9)
	ML = 9.59 + 19.22 LCL	(r^2=0.78, n=9)	ln WtP = -1.18 ++ 2.63 ln LCL	(r^2=0.86, n=9)
Teuthowenia pellucida	ML = 15.51 + 10.39 LRF	(r^2=0.87, n=41)	ln WtP = -2.16 + 2.25 ln LRF	(r^2=0.97, n=41)
	ML = 17.02 + 30.56 LHL	(r^2=0.86, n=40)	ln WtP = 0.29 + 2.28 ln LHL	(r^2=0.95, n=40)
	ML = 11.49 + 16.55 LCL	(r^2=0.88, n=39)	ln WtP = -1.50 + 2.41 ln LCL	(r^2=0.96, n=39)

APPENDIX 7: Additional equations for estimating size and weight of Octopoda and Vampyromorpha from upper beak dimensions.

Species	Equations for estimating mantle length (ML) in mm.		Equations for estimating fresh (WtF) or preserved (WtP) weight in g.	
Grimpoteuthis sp.	$ML = -51.51 + 8.59\ UCL$	(r^2=1.00, n=2)	N/A	
Opisthoteuthis persephone	$ML = -10.24 + 3.23\ UCL$	(r^2=0.78, n=32)	$\ln WtP = -3.91 + 3.67 \ln UCL$	(r^2=0.94, n=33)
Opisthoteuthis pluto	$ML = 1.22 + 2.91\ UCL$	(r^2=0.82, n=7)	$\ln WtP = -0.20 + 2.32 \ln UCL$	(r^2=0.73, n=7)
Octopus berrima	$ML = -5.45 + 5.18\ UCL$	(r^2=0.80, n=34)	$\ln WtP = -3.02 + 3.11 \ln UCL$	(r^2=0.93, n=34)
Octopus bunurong	n/s		$\ln WtP = -4.02 + 3.63 \ln UCL$	(r^2=0.98, n=11)
Octopus kaurna	$ML = -14.52 + 9.20\ UCL$	(r^2=0.52, n=26)	$\ln WtP = -2.21 + 3.05 \ln UCL$	(r^2=0.76, n=26)
Octopus maorum	$ML = -68.51 + 8.14\ UCL$	(r^2=0.89, n=14)	$\ln WtP = -2.79 + 2.99 \ln UCL$	(r^2=0.96, n=10)
Octopus pallidus	$ML = -8.59 + 5.36\ UCL$	(r^2=0.68, n=42)	$\ln WtP = -3.28 + 3.10 \ln UCL$	(r^2=0.96, n=24)
Octopus superciliosus	$ML = -9.71 + 5.61\ UCL$	(r^2=0.79, n=10)	$\ln WtP = -4.71 + 3.82 \ln UCL$	(r^2=0.90, n=10)
Octopus warringa	n/s		$\ln WtP = -3.28 + 2.96 \ln UCL$	(r^2=0.87, n=9)
Hapalochlaena maculosa	$ML = -3.08 + 6.53\ UCL$	(r^2=0.70, n=31)	$\ln WtP = -2.76 + 3.53 \ln UCL$	(r^2=0.70, n=31)
Eledone palari	$ML = -8.92 + 9.94\ UCL$	(r^2=0.68, n=10)	$\ln WtP = -1.53 + 3.16 \ln UCL$	(r^2=0.81, n=10)
Ocythoe turberculata	$ML = -2.37 + 2.92\ UCL$	(r^2=0.95, n=11)	$\ln WtP = -4.67 + 3.12 \ln UCL$	(r^2=0.97, n=11)
Argonauta nodosa	$ML = -57.67 + 9.02\ UCL$	(r^2=0.81, n=12)	$\ln WtP = -3.98 + 3.20 \ln UCL$	(r^2=0.89, n=12)
Vampyroteuthis infernalis	$ML = 8.06 + 2.62\ UCL$	(r^2=0.52, n=10)	$\ln WtP = -3.95 + 2.98 \ln UCL$	(r^2=0.78, n=10)



a = rostrum length
b = hood length
c = crest length
d = rostrum to wing base length
e = rostrum to free corner length
f = baseline length

Fig. 1. Beak measurements; (A) of upper beak, (B) of lower beak.

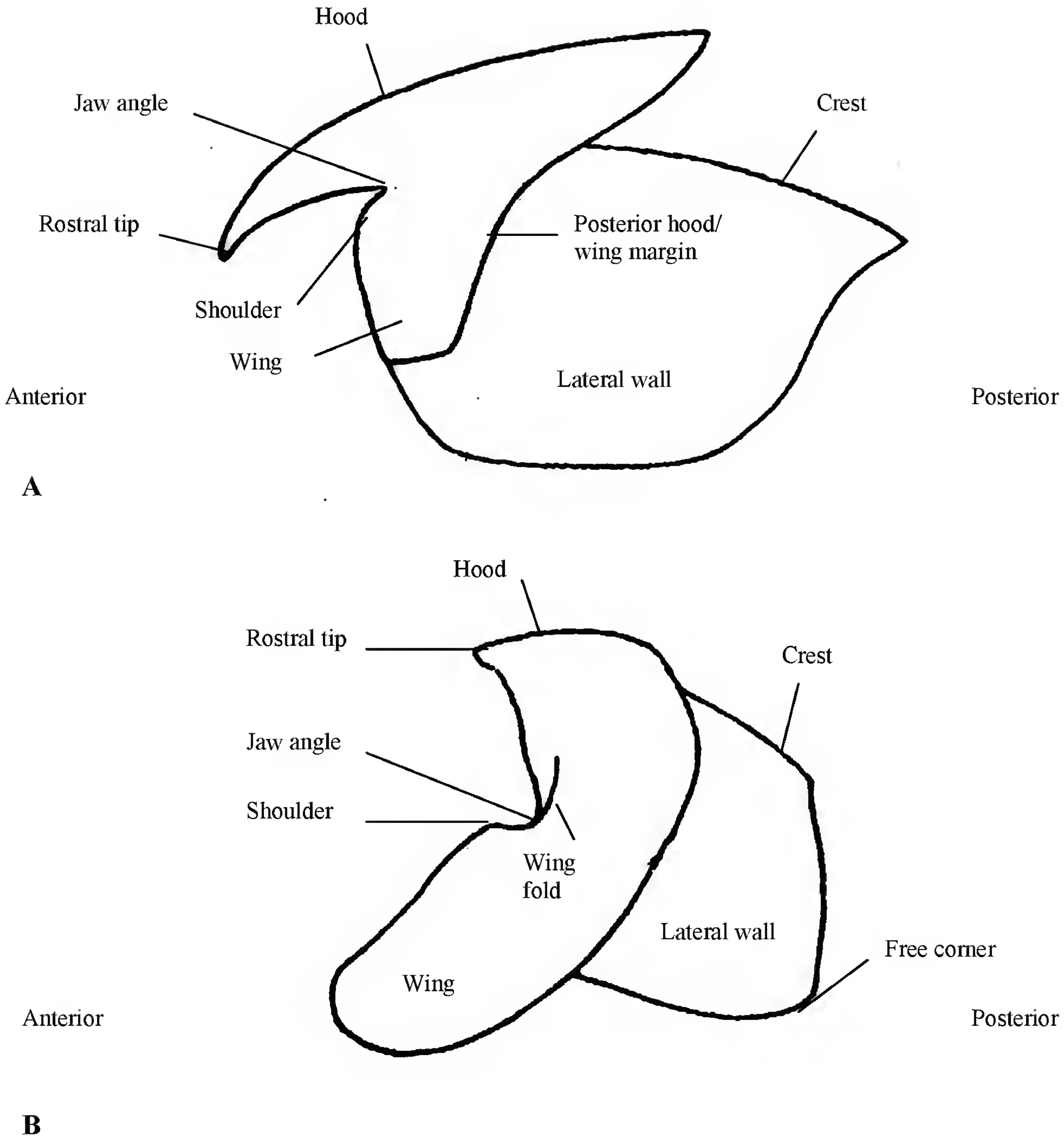
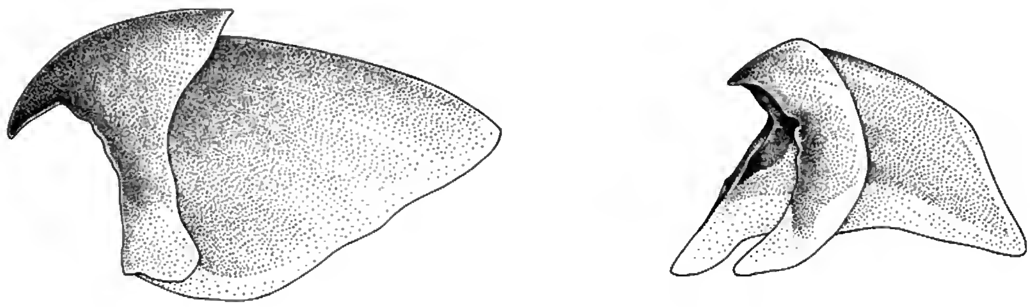


Fig. 2. Beak characteristics used for description; (*A*) of upper beak, (*B*) of lower beak



A **B**

Fig. 3. *Spirula spirula*: (*A, B*) MV F77018, male, 39.5mmML, 7.75g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

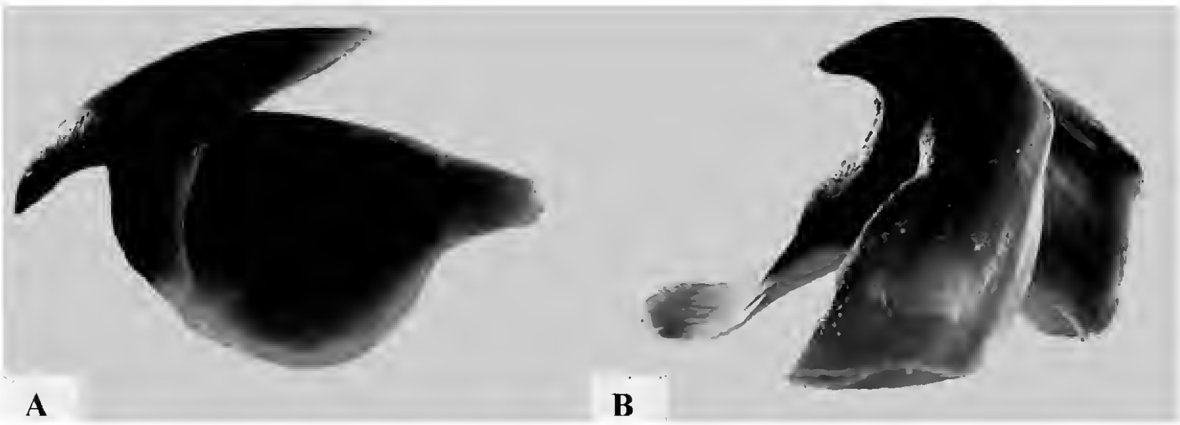
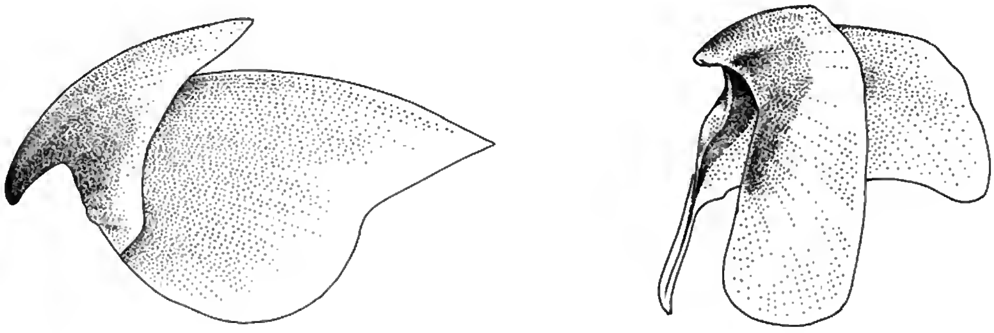


Fig. 4. *Sepia apama*: (*A, B*) MV 82721, female, 242mmML, 1335g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.



A **B**

Fig. 5. *Sepia braggi*: (*A, B*) MV F52139, female, 79.0mmML, 22.6g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

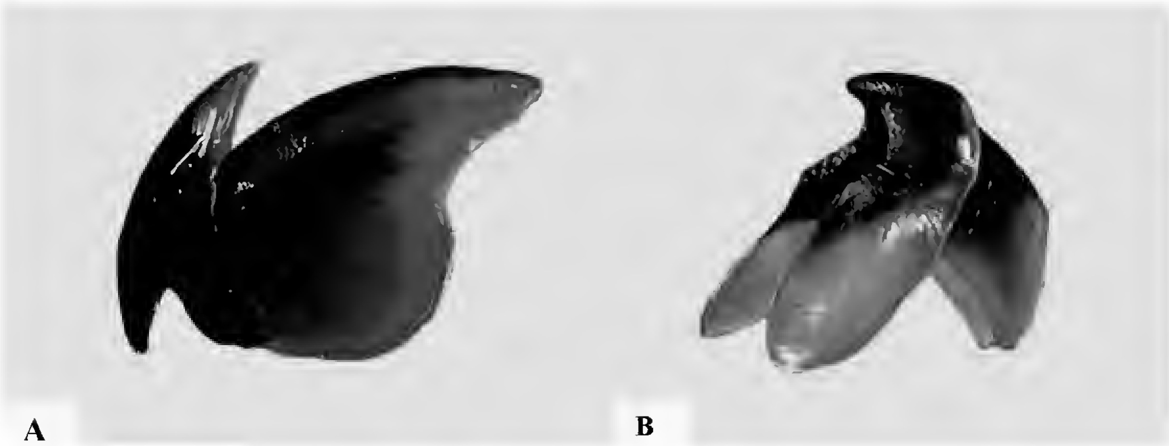


Fig. 6. *Sepia chirotrema*: (*A, B*) MV F66201, female, 123.0mmML, 116g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

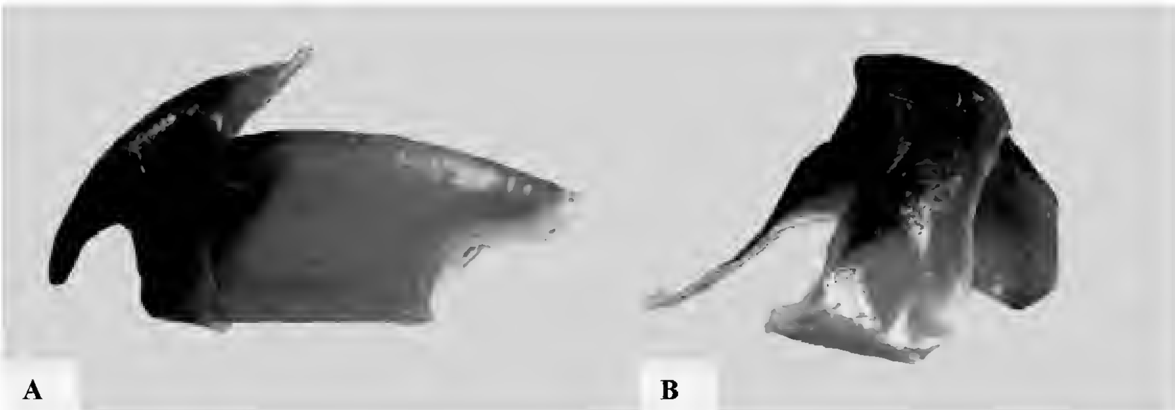


Fig. 7. *Sepia cultrata*: (*A, B*) MV F52303, female, 87.6mmML, 63.8g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

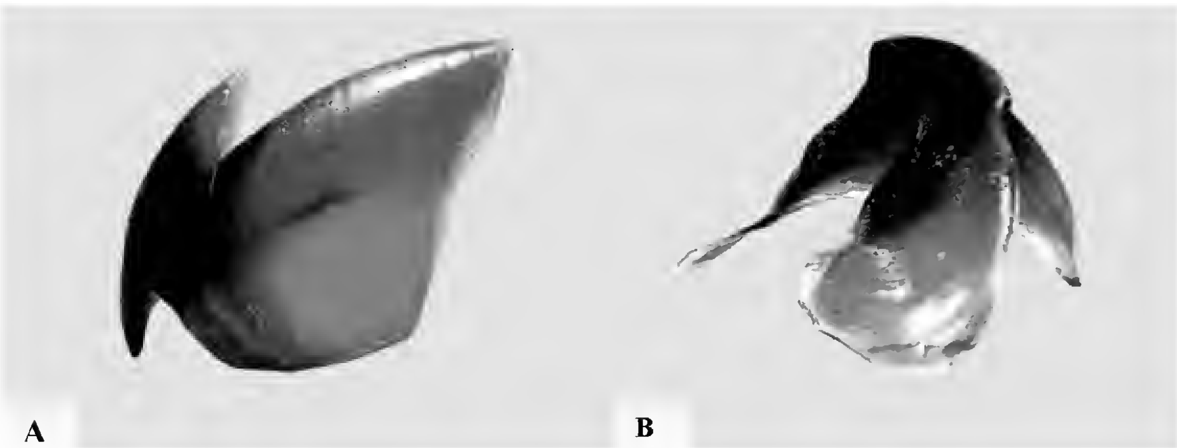


Fig. 8. *Sepia hedleyi*: (*A, B*) MV F30332, female, 98.1mmML, 81.4g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

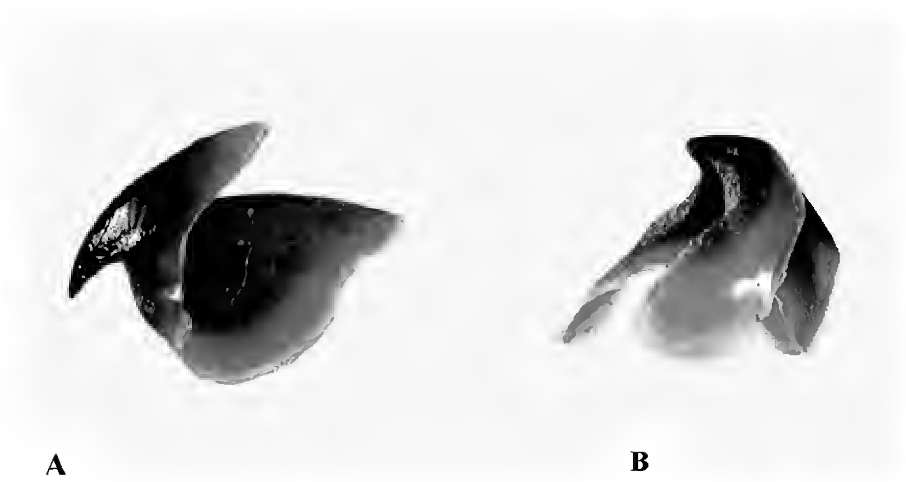


Fig. 9. *Sepia irvingi*: (*A, B*) MV F56768, female, 128.9mmML, 246.3g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

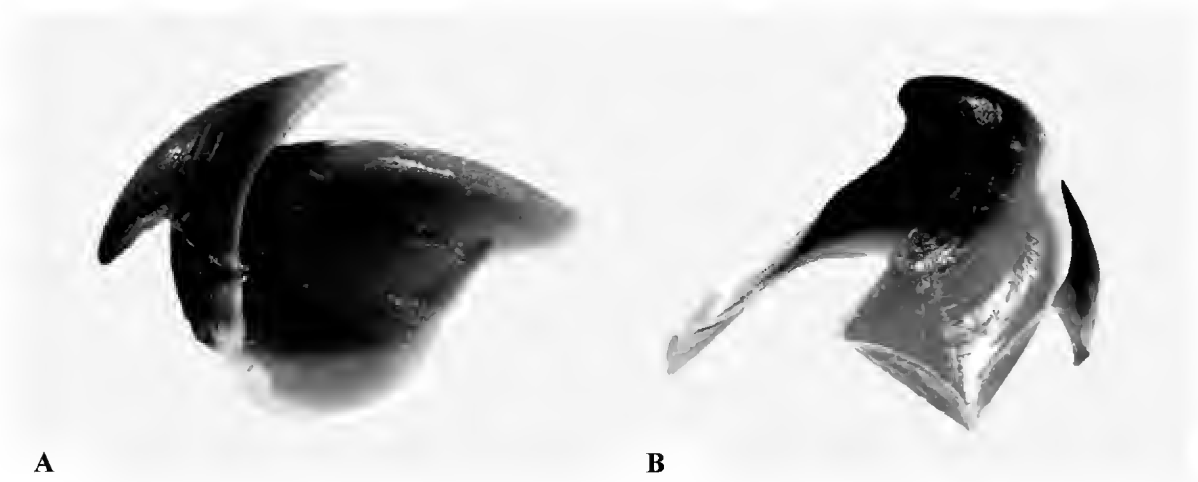


Fig. 10. *Sepia mestus*: (*A, B*) MV F82722, female, 99.6mmML, 109.1g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

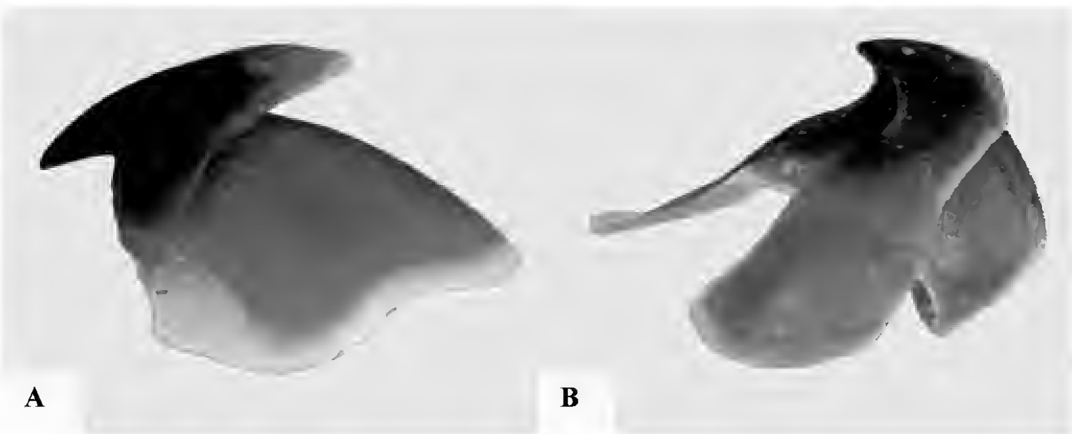


Fig. 11. *Sepia novaehollandiae*: (*A, B*) MV F30864, female, 72.6mmML, 44.9g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

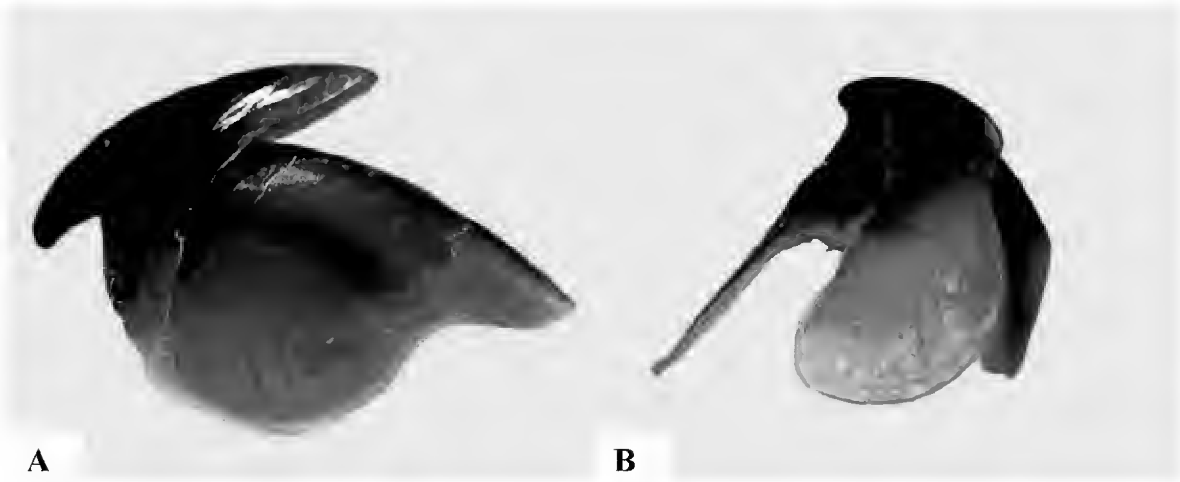


Fig. 12. *Sepia plangon*: (*A, B*) MV F57289, male, 93.0mmML, 59.0g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

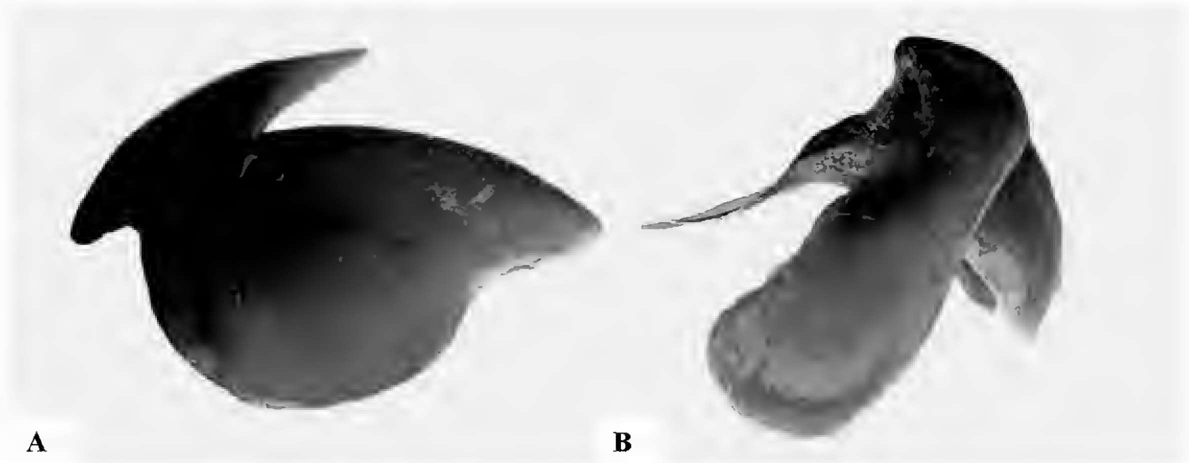


Fig. 13. *Sepia rozella*: (*A, B*) MV F57322, male, 100.5mmML, 111.6g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

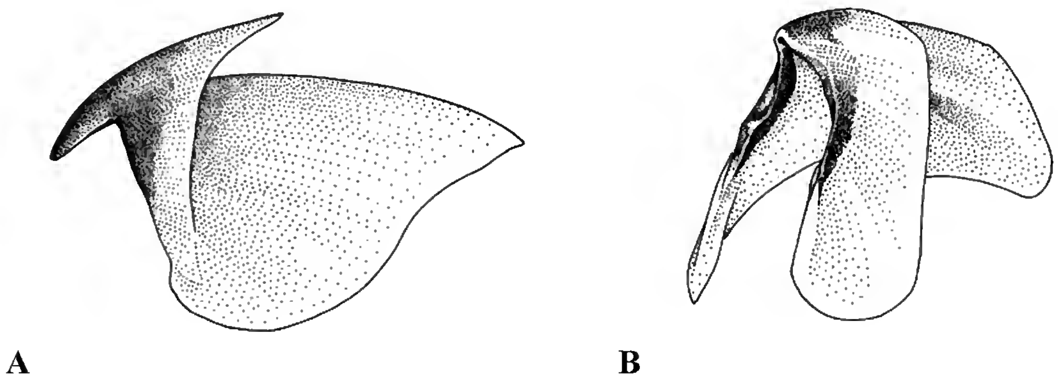
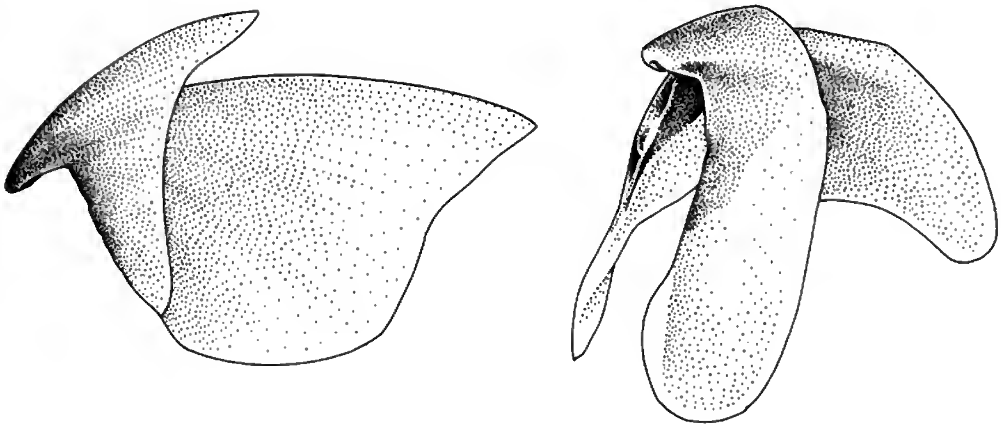
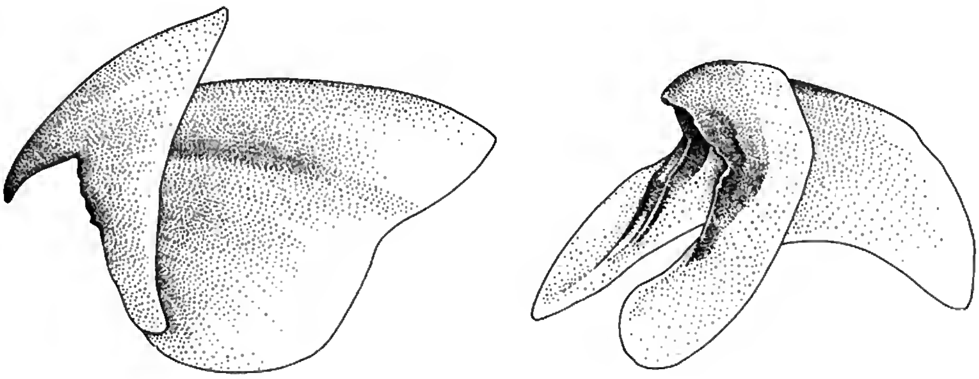


Fig. 14. Sepiadarium austrinum: (A, B) MV 88286, female, 26.6mmML, 4.6g WtP; (A) upper beak, side view and (B) lower beak, oblique view.



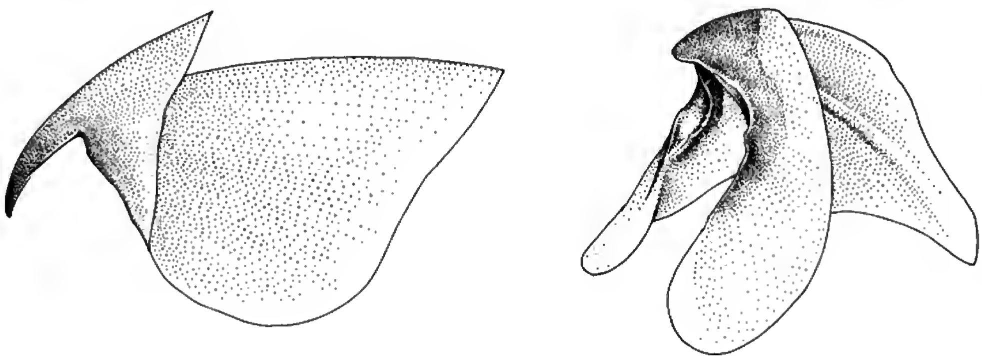
A **B**

Fig. 15. *Sepioloidea lineolata*: (*A, B*) MV F88287, female, 26.3mmML, 10.6g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.



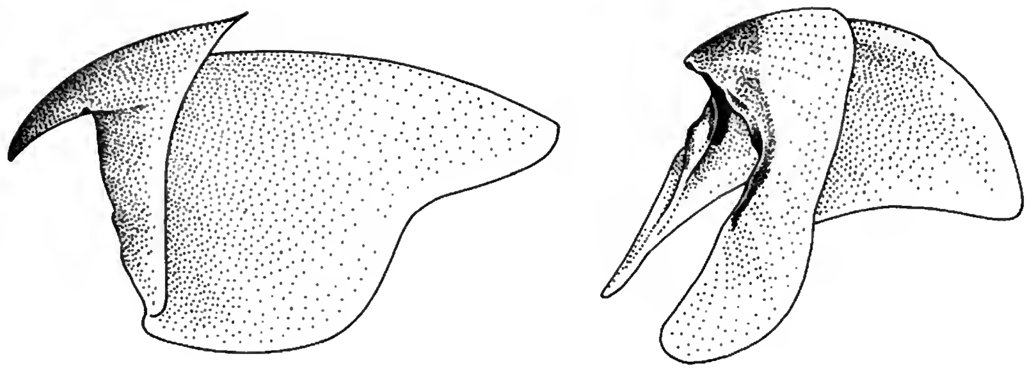
A **B**

Fig. 16. *Rossia australis*: (*A, B*) MV F57493, female, 50.0mmML, 20.2g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.



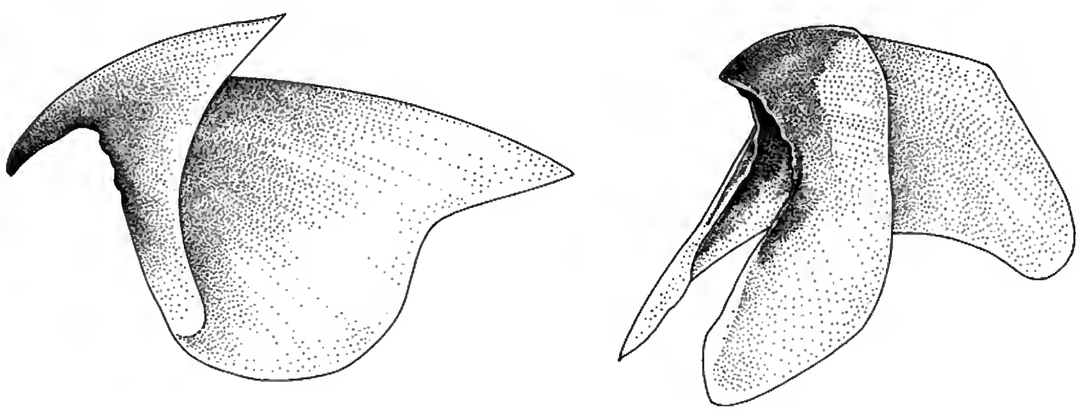
A **B**

Fig. 17. *Heteroteuthis serventyi*: (*A, B*) MV F51410, 25.8mmML, 4.6g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.



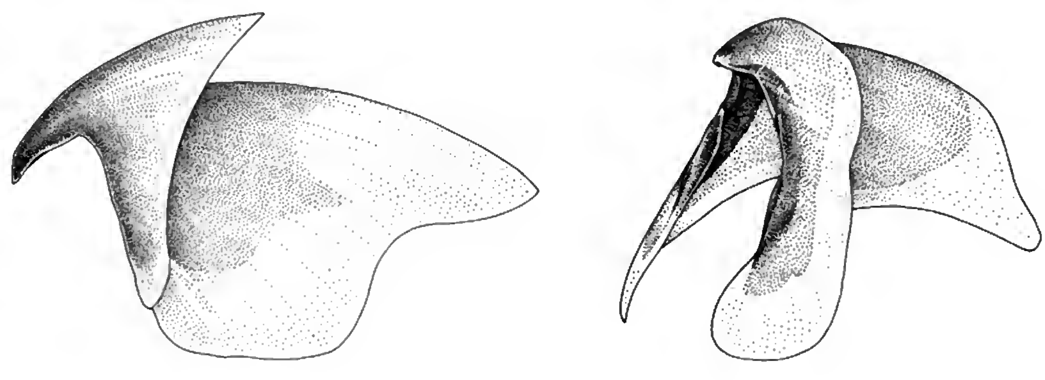
A **B**

Fig. 18. *Iridoteuthis* sp.: (*A, B*) MV F68306, male, 17.8mmML, 3.0g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.



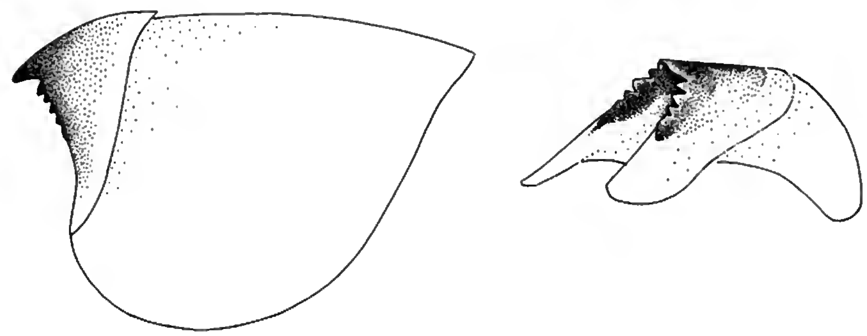
A **B**

Fig. 19. *Sepiolina nipponensis*: (*A, B*) MV F71714, 22.4mmML, 3.7g WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.



A **B**

Fig. 20. *Euprymna tasmanica*: (*A, B*) MV F4805, female, 30.2mmML, 11.42 WtP; (*A*) upper beak, side view and (*B*) lower beak, oblique view.



A **B**

Fig. 21.*Idiosepius notoides*: (*A, B*) MV F88288, female, 16.0mmML; (*A*) upper beak, side view and (*B*) lower beak, oblique view.

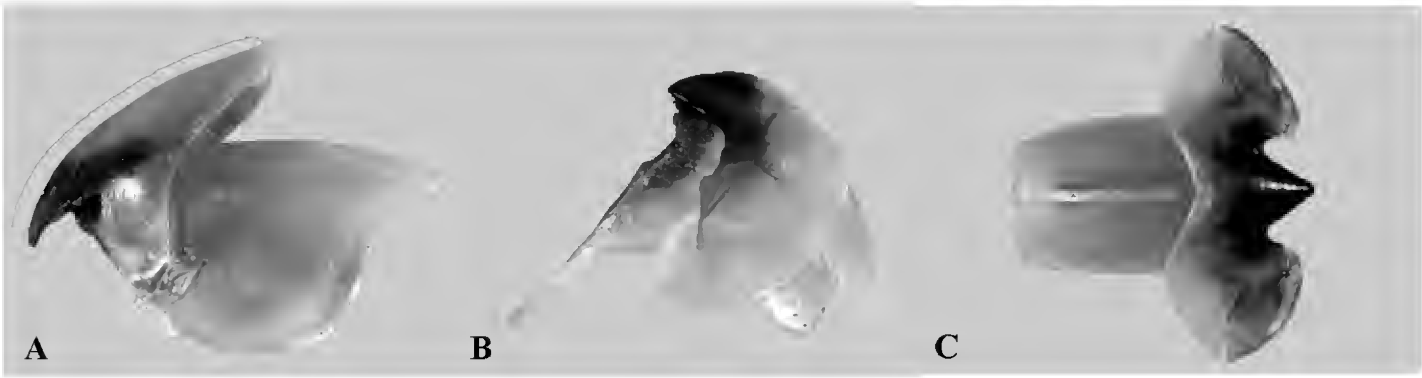
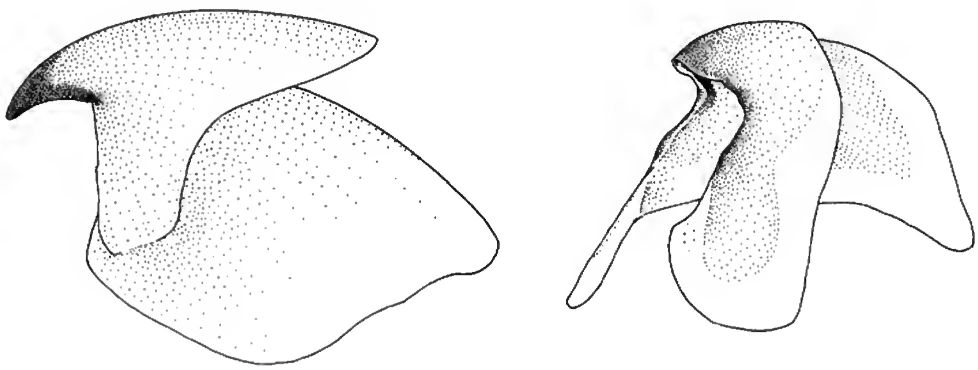


Fig. 22. *Sepioteuthis australis*: (A-C) MV F30851; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.



A **B**

Fig. 23. *Loliolus noctiluca*: (A, B) MV F80428; (A) upper beak, side view, (B) lower beak, oblique view

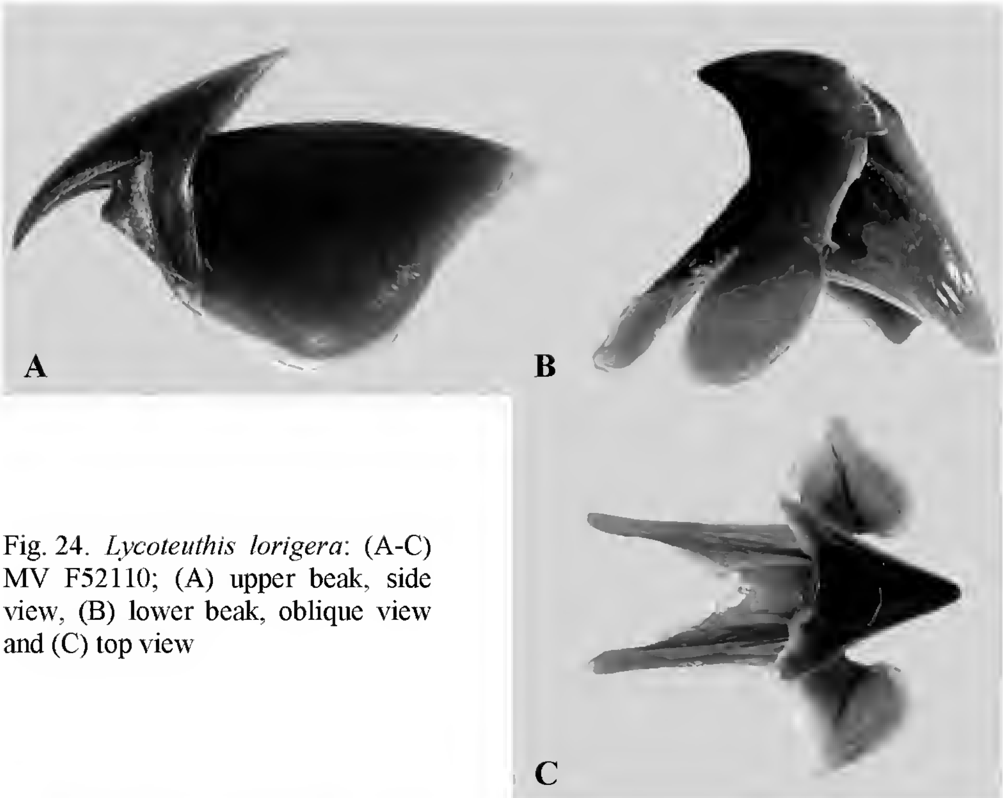


Fig. 24. *Lycoteuthis lorigera*: (A-C) MV F52110; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view

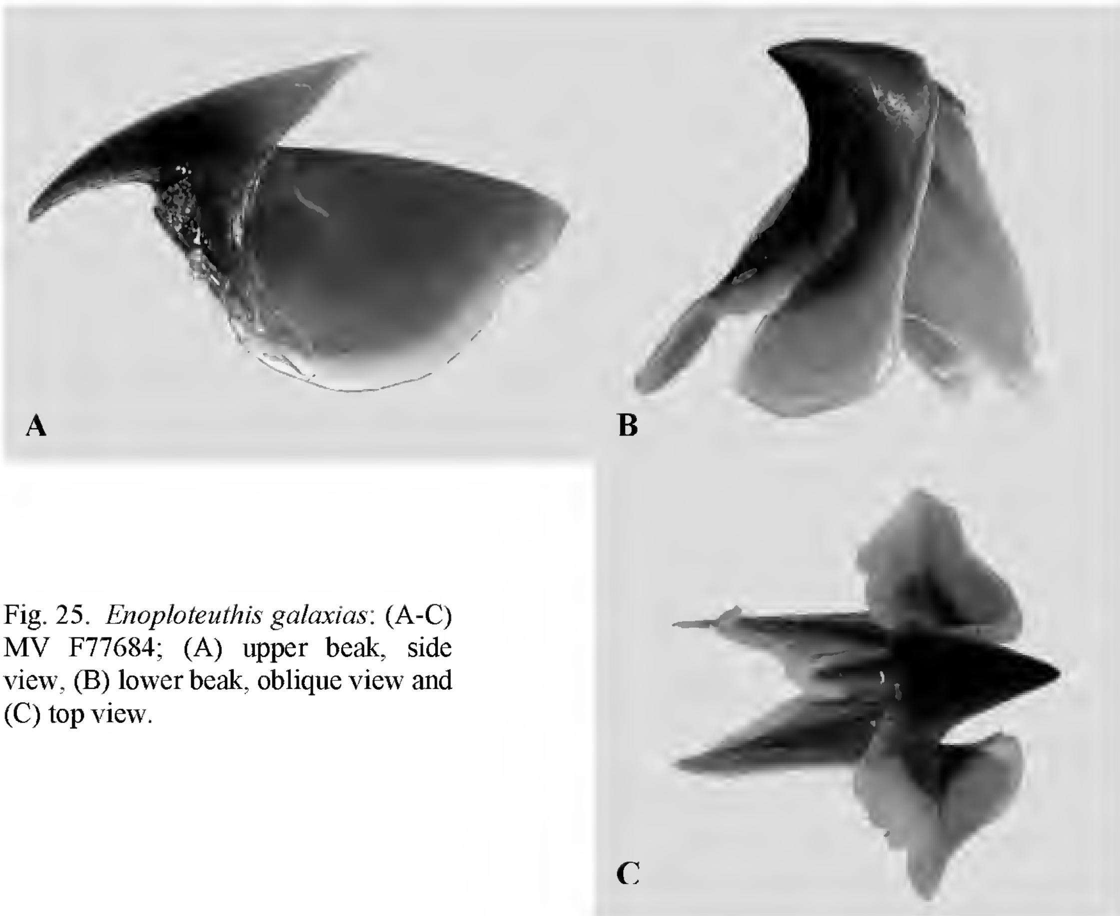


Fig. 25. *Enoploteuthis galaxias*: (A-C) MV F77684; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

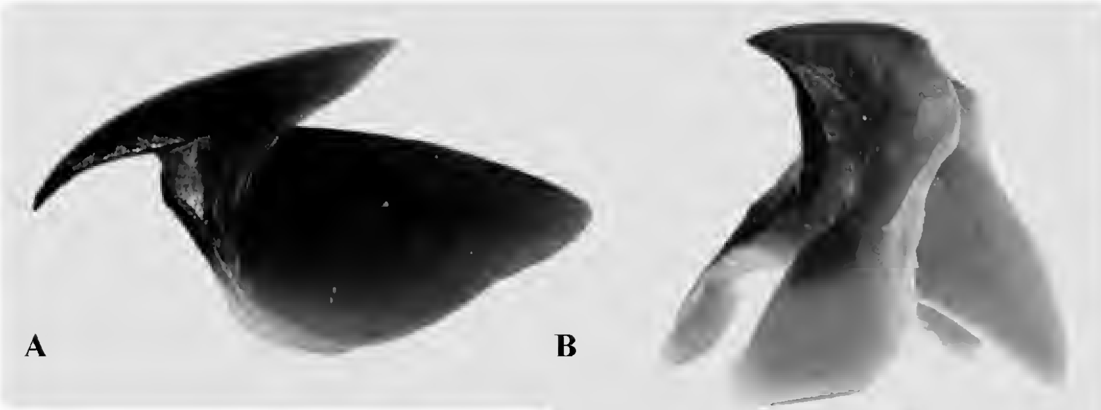
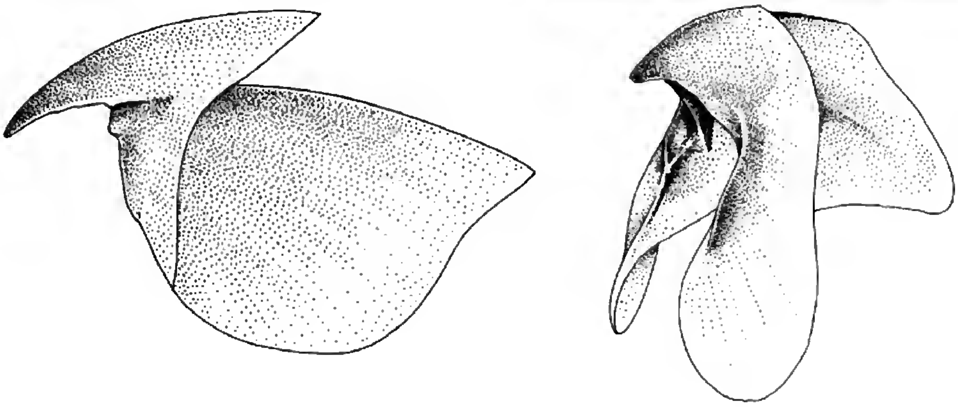
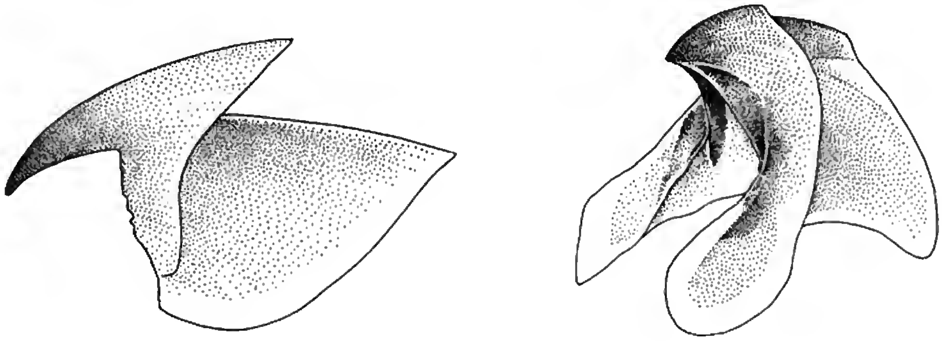


Fig. 26. *Enoploteuthis* sp.: (A-C) MV F89690; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view



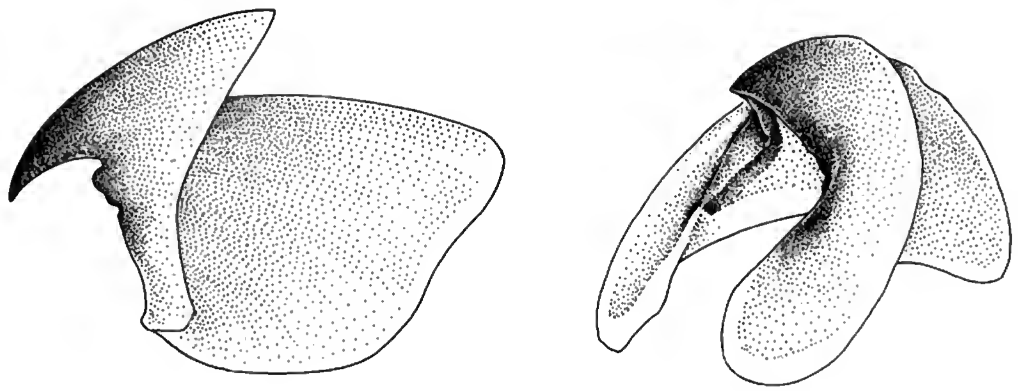
A B

Fig. 27. *Abraliopsis gilchristi*: (A, B) MV F77834; (A) upper beak, side view, (B) lower beak, oblique view



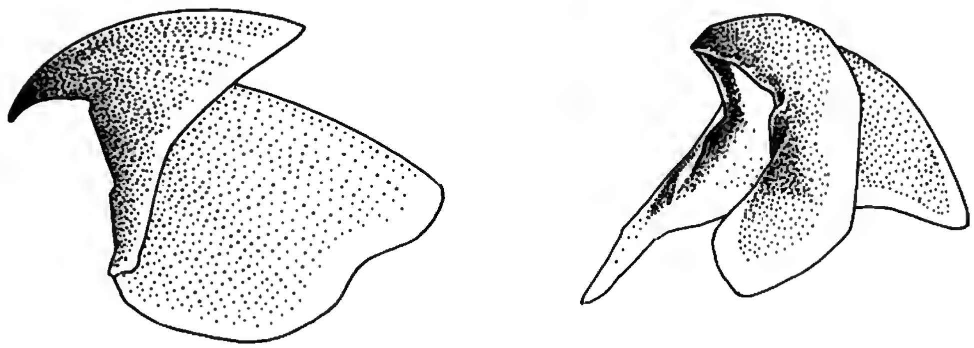
A B

Fig. 28. *Abraliopsis tui*: (A, B) MV F77904; (A) upper beak, side view, (B) lower beak, oblique view



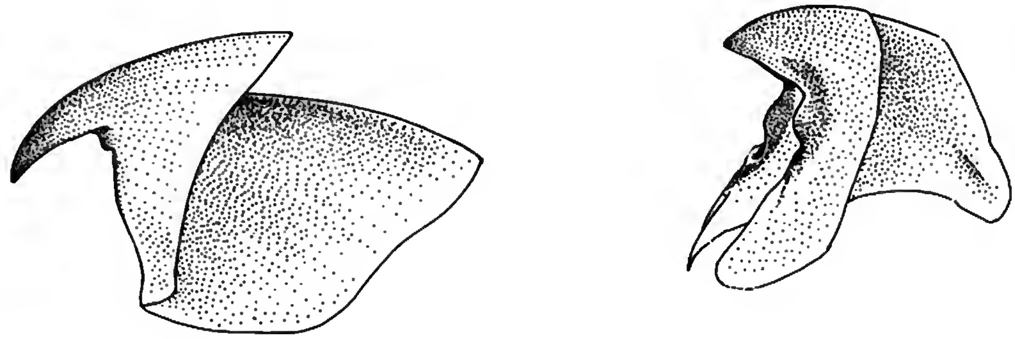
A **B**

Fig. 29. *Pyroteuthis margaritifera*: (A, B) MV F78127; (A) upper beak, side view, (B) lower beak, oblique view



A **B**

Fig. 30. *Pterygioteuthis gemmata*: (A, B) MV F50842; (A) upper beak, side view, (B) lower beak, oblique view



A **B**

Fig. 31. *Pterygioteuthis giardi*: (A, B) MV F80423; (A) upper beak, side view, (B) lower beak, oblique view

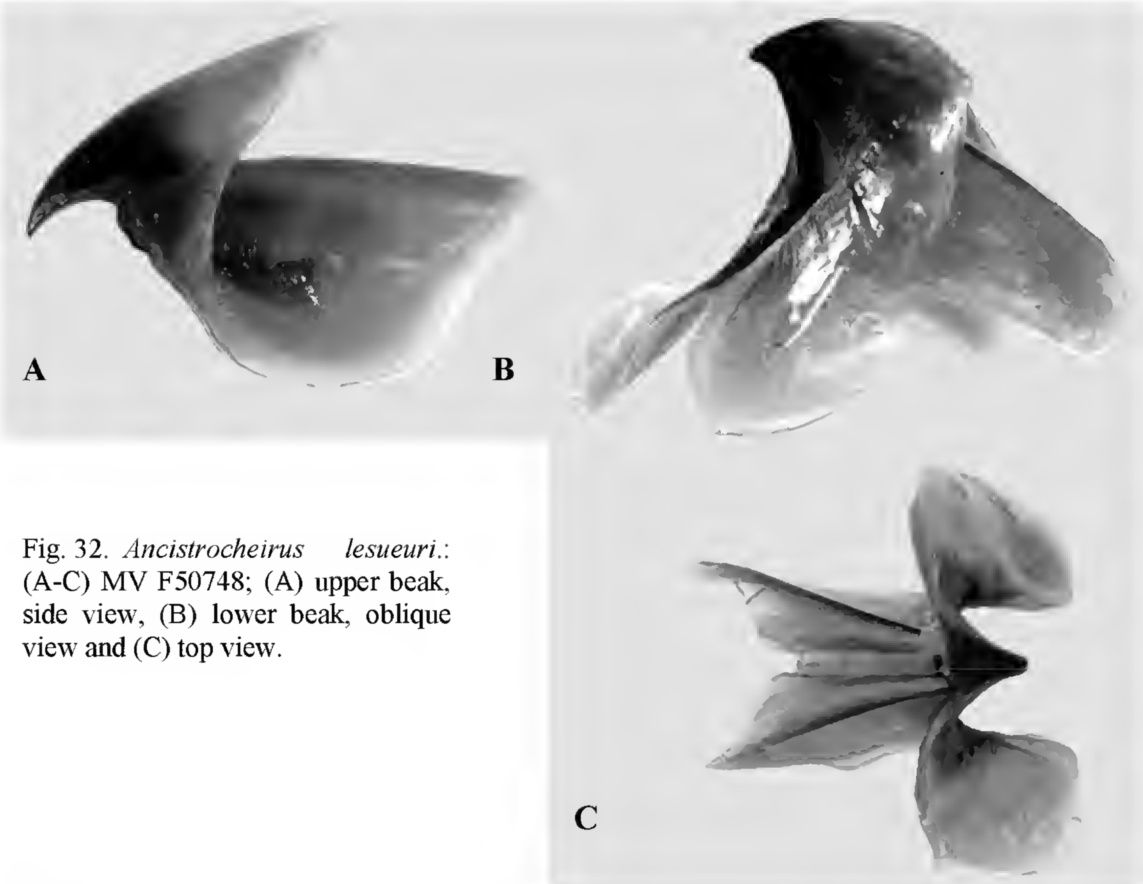


Fig. 32. *Ancistrocheirus lesueuri*.: (A-C) MV F50748; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

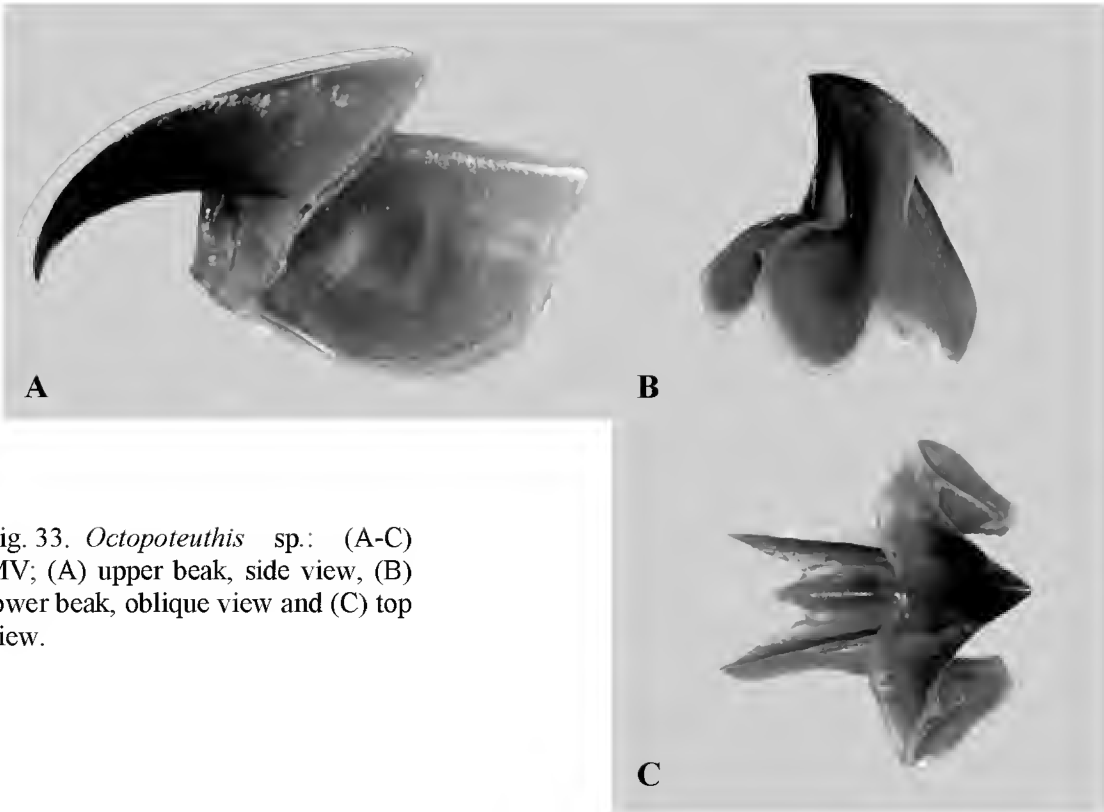


Fig. 33. *Octopoteuthis* sp.: (A-C) MV; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

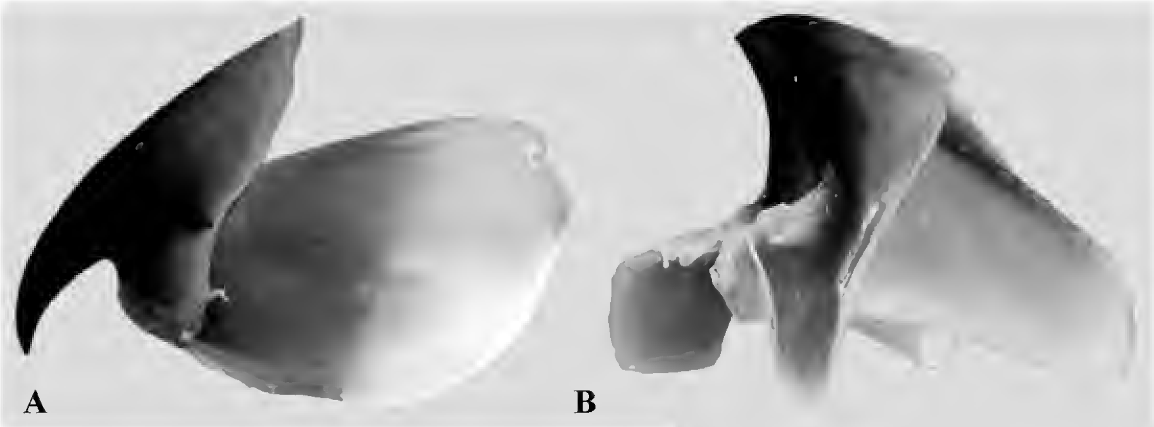


Fig. 34. *Taningia danae*: (A-C) MV F80327; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

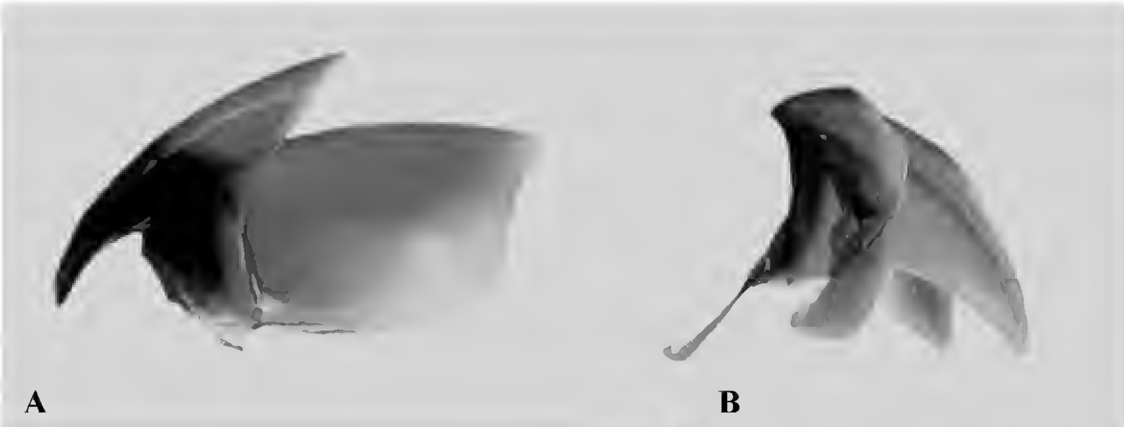


Fig. 35. *Onychoteuthis banskii*: (A-C) MV F51001; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

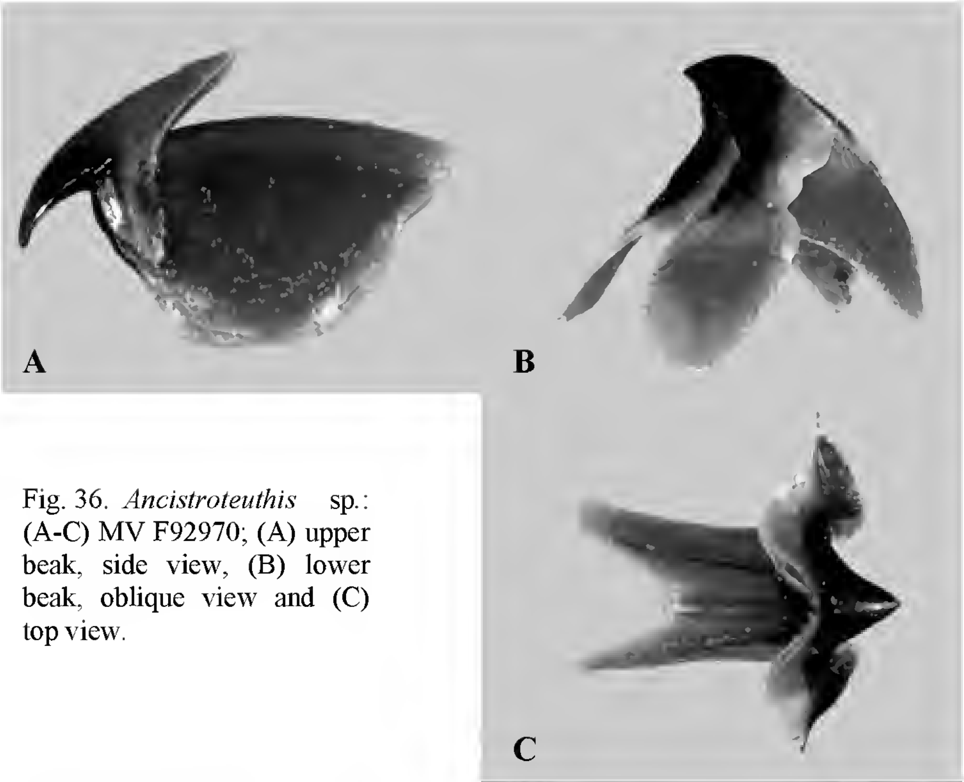


Fig. 36. *Ancistroteuthis* sp.: (A-C) MV F92970; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

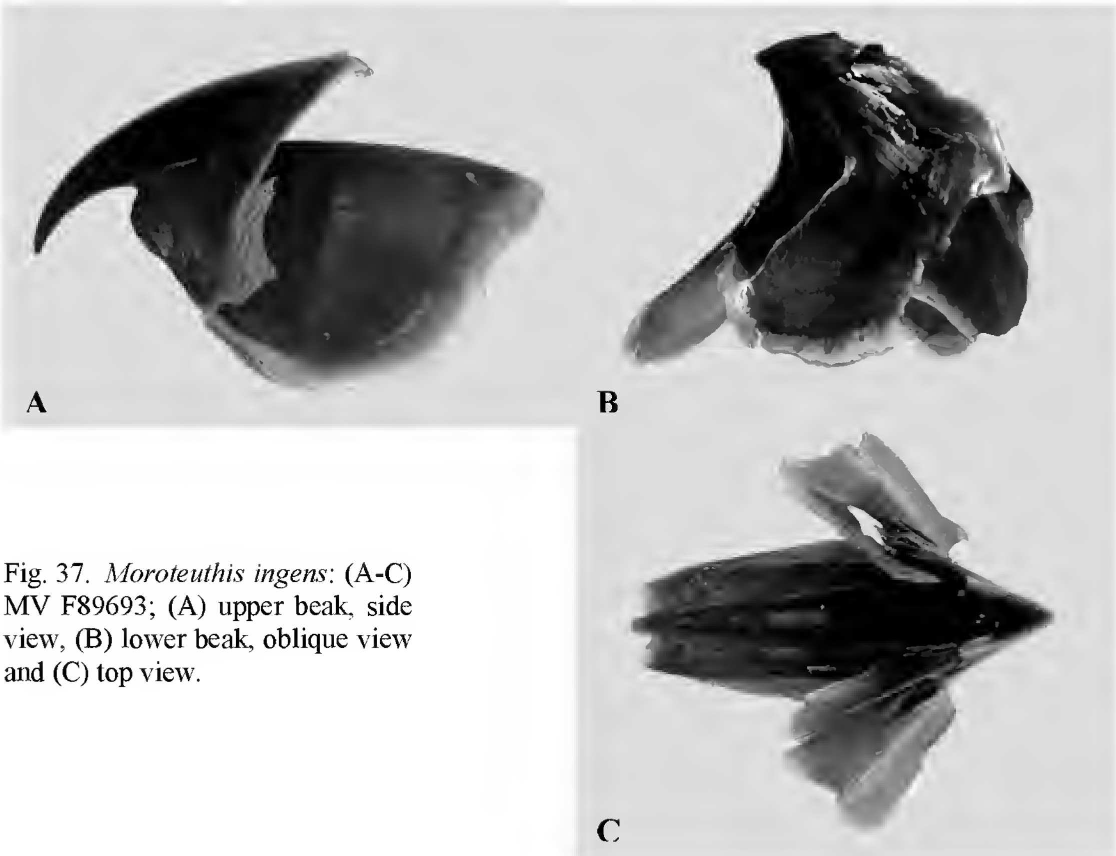


Fig. 37. *Moroteuthis ingens*: (A-C) MV F89693; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

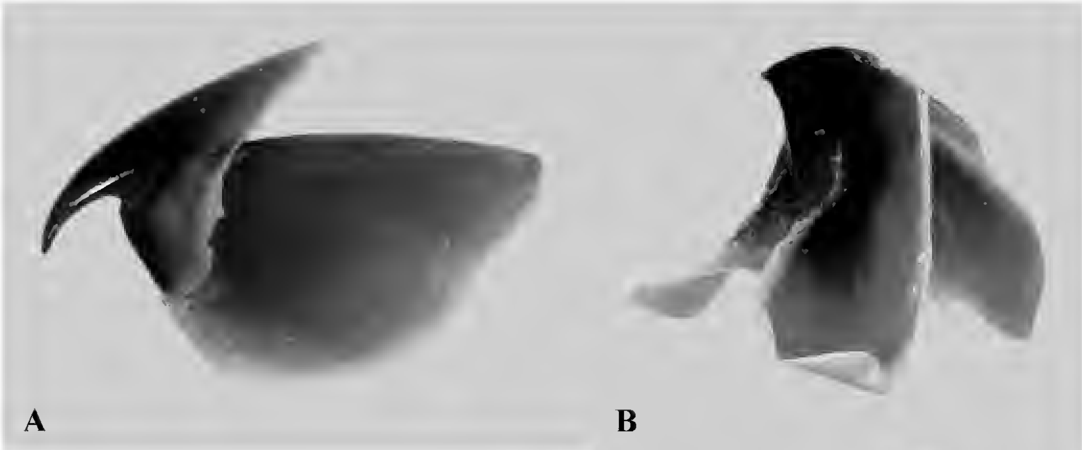


Fig. 38. *Moroteuthis robsoni*: (A-C) MV F 89689; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

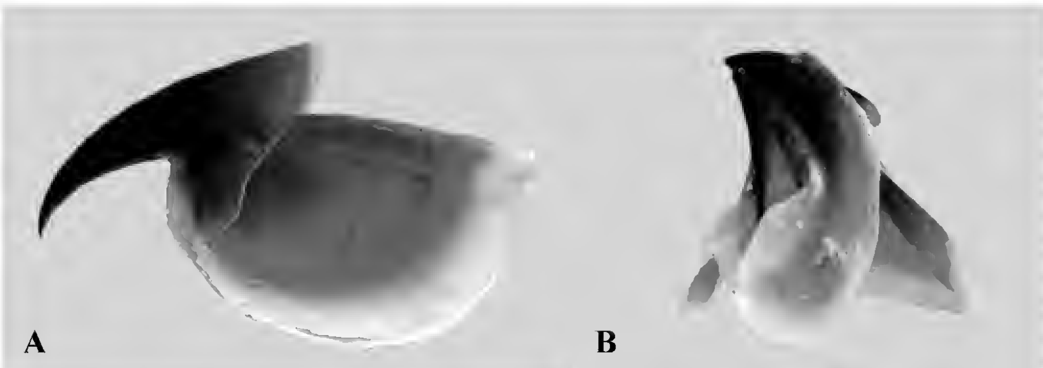


Fig. 39. *Lepidoteuthis grimaldi*: (A-C) MV F 53159; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

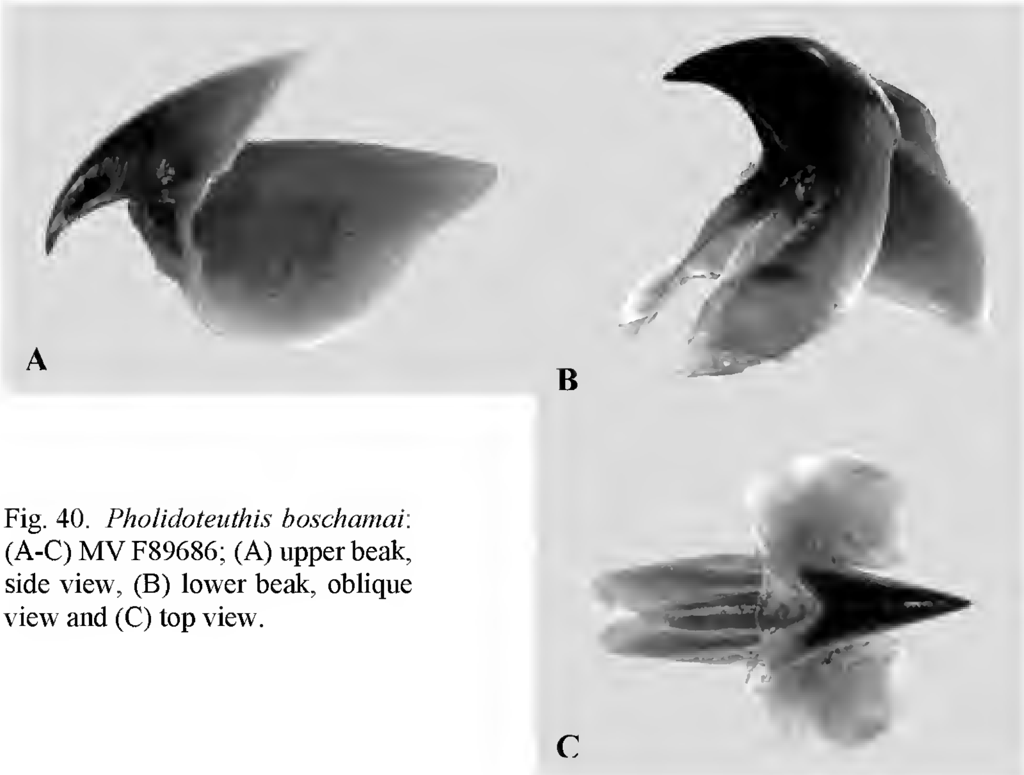


Fig. 40. *Pholidoteuthis boschamai*: (A-C) MV F89686; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

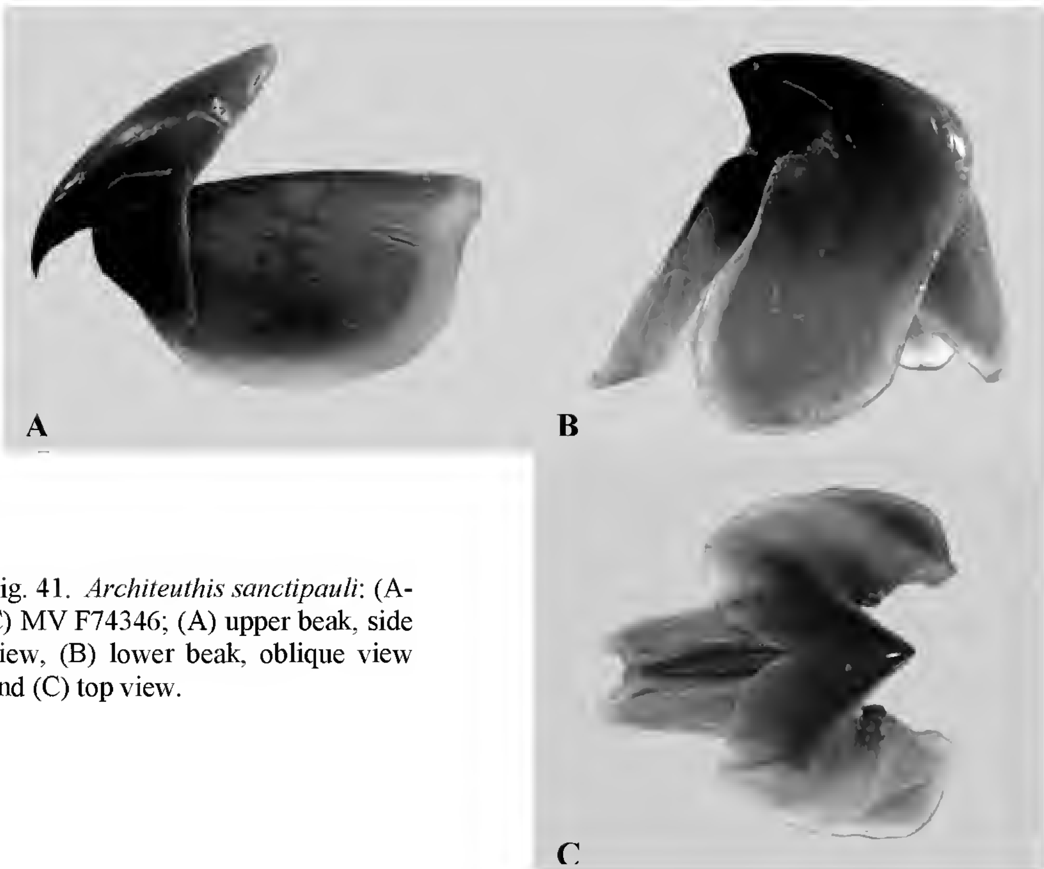


Fig. 41. *Architeuthis sanctipauli*: (A-C) MV F74346; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

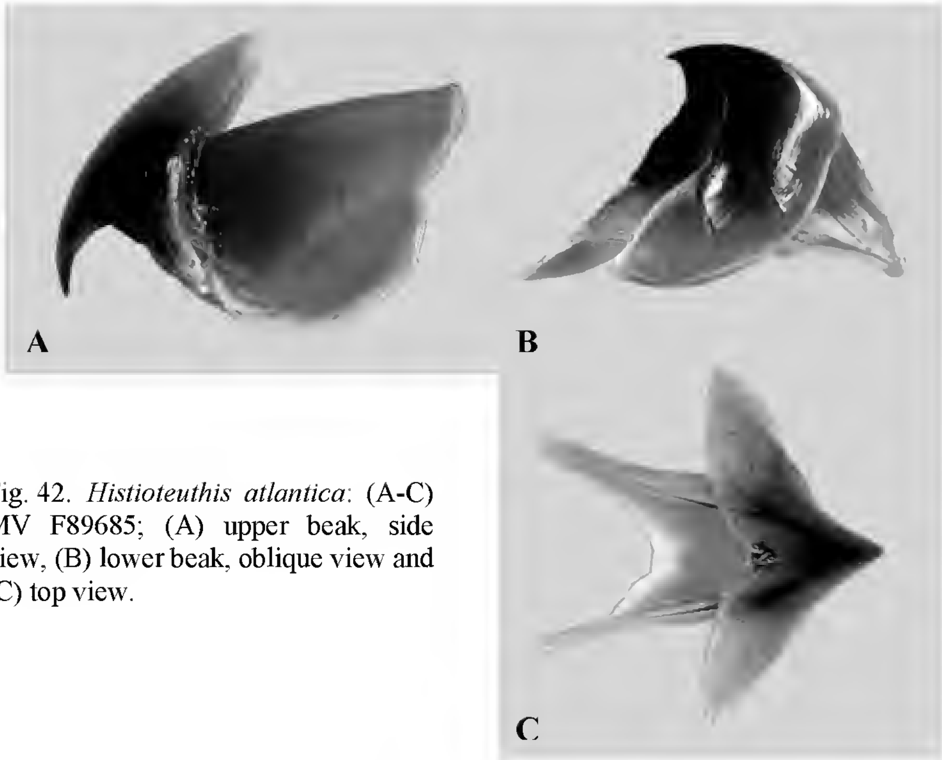


Fig. 42. *Histioteuthis atlantica*: (A-C) MV F89685; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

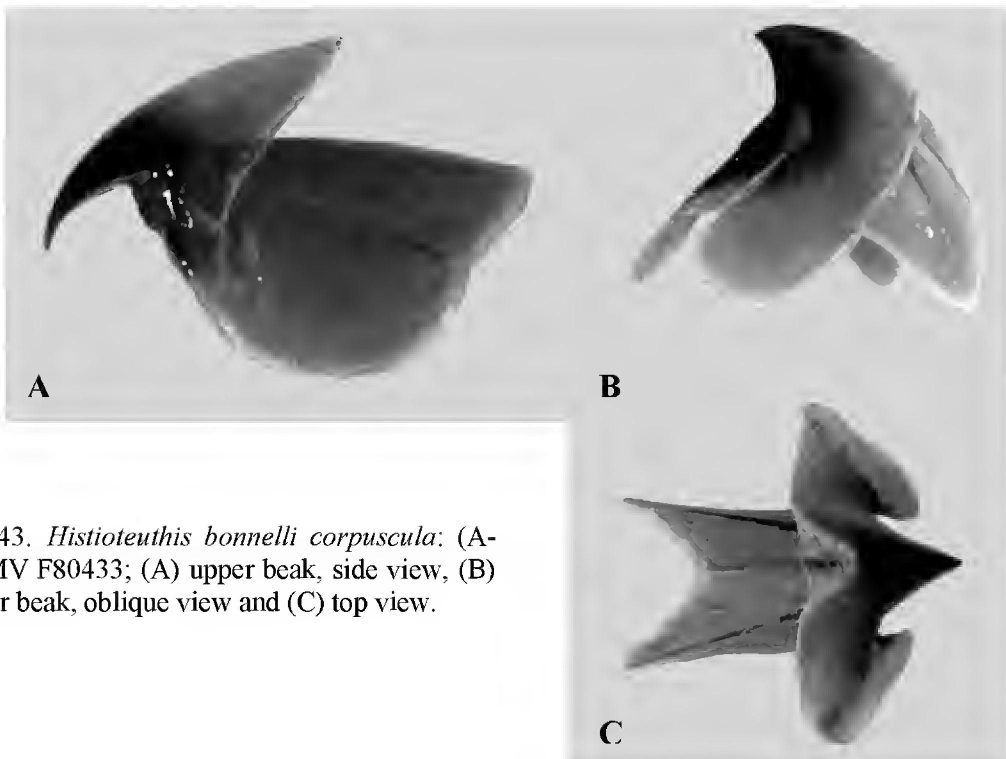


Fig. 43. *Histioteuthis bonnelli corpuscula*: (A-C) MV F80433; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

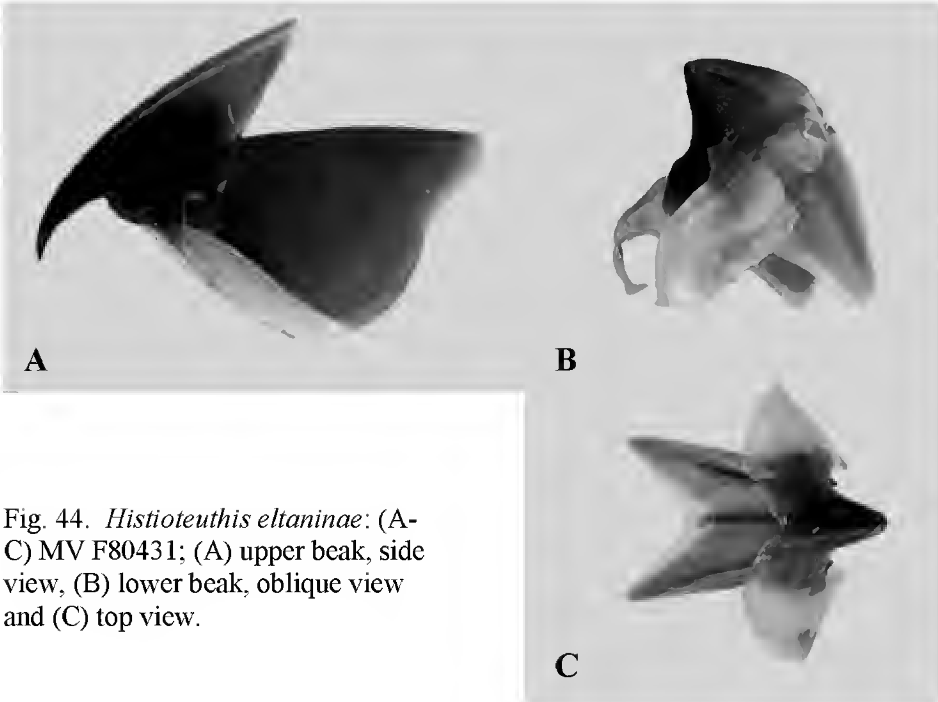


Fig. 44. *Histioteuthis eltaninae*: (A-C) MV F80431; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

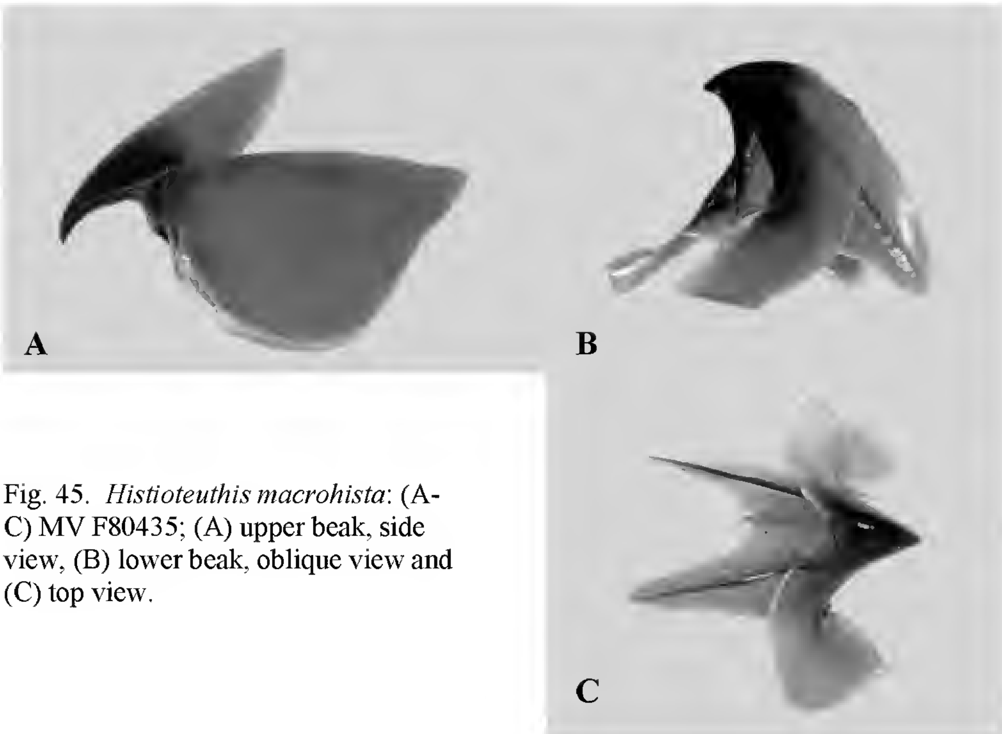


Fig. 45. *Histioteuthis macrohista*: (A-C) MV F80435; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

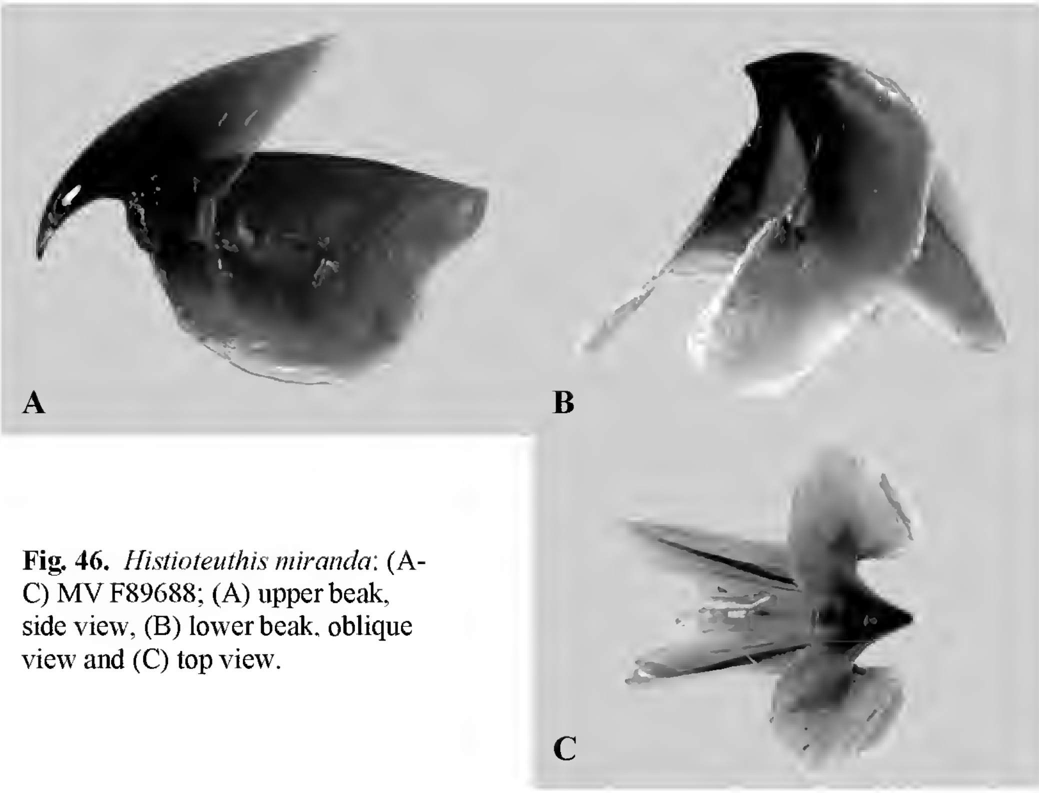


Fig. 46. *Histioteuthis miranda*: (A-C) MV F89688; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

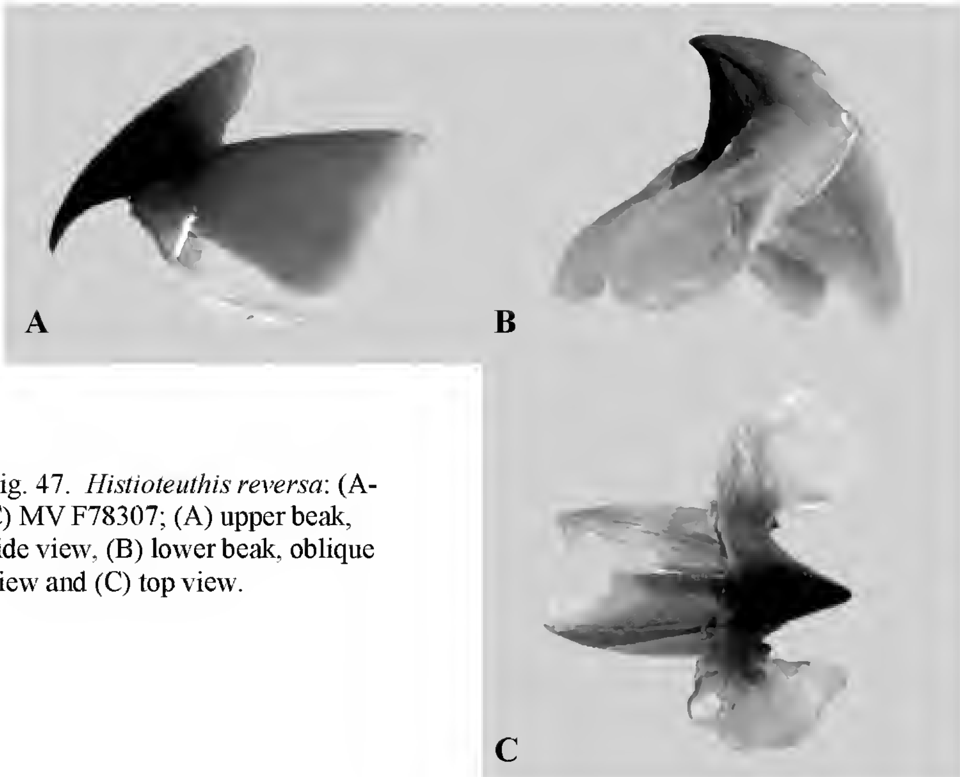
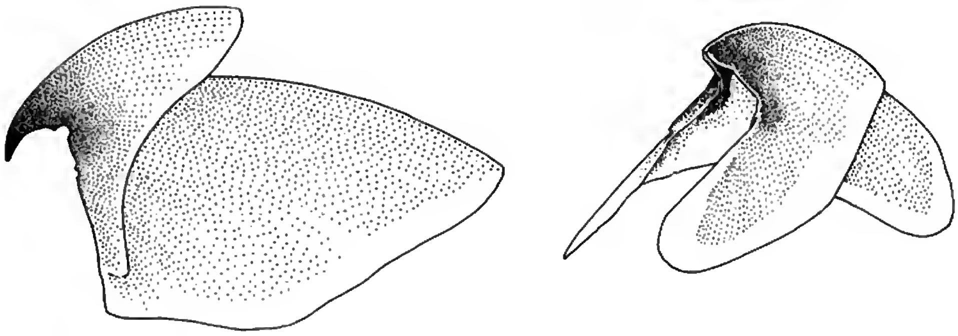
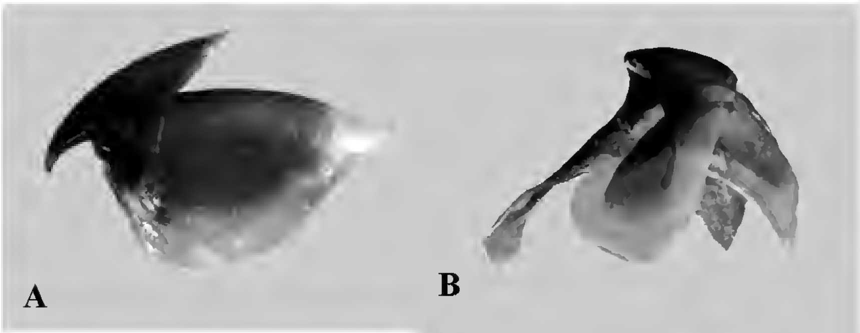


Fig. 47. *Histioteuthis reversa*: (A-C) MV F78307; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.



A B

Fig. 48. *Bathyteuthis abyssicola*: (A, B) MVF51179; (A) upper beak, side view, (B) lower beak, oblique view.



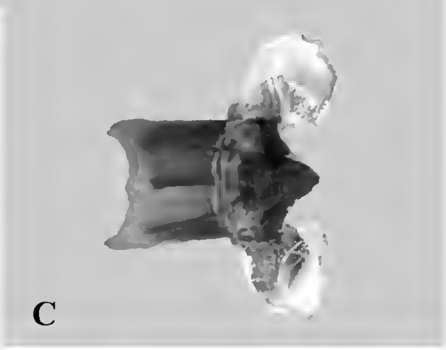


Fig. 49. *Ctenopteryx siculus*: (A-C) MV; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

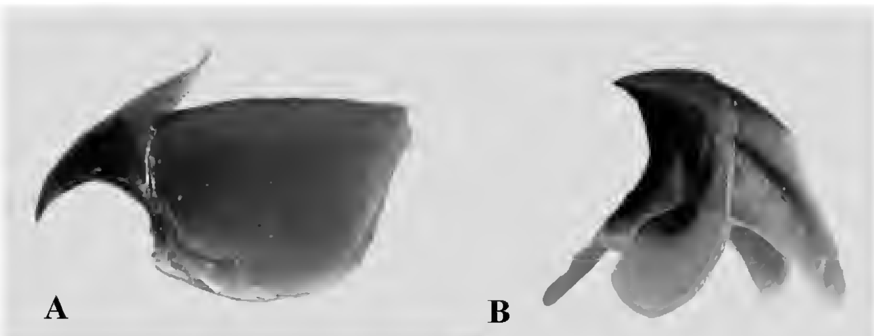
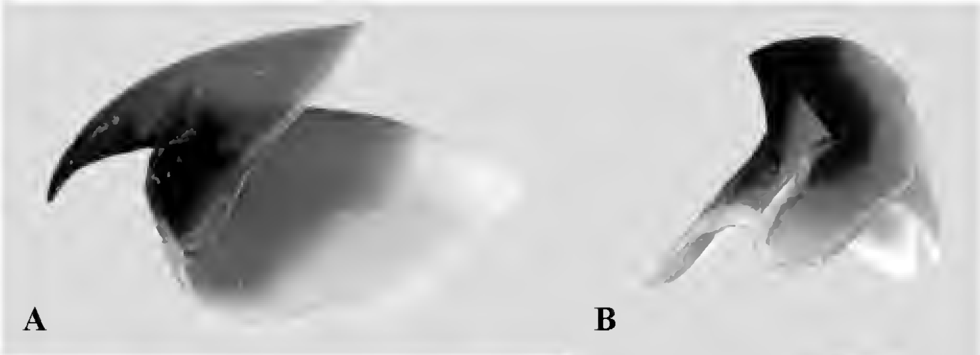


Fig. 50. *Brachioteuthis* cf. *riisei*: (A-C) MV F52126; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.



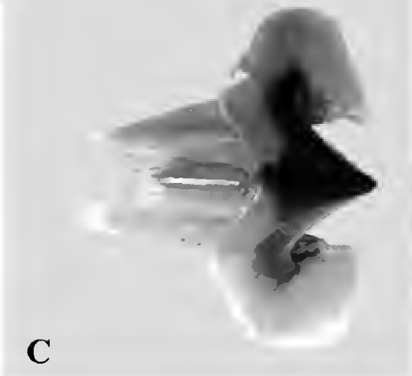


Fig. 51. *Todaropsis eblane*: (A-C) MV F31125; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

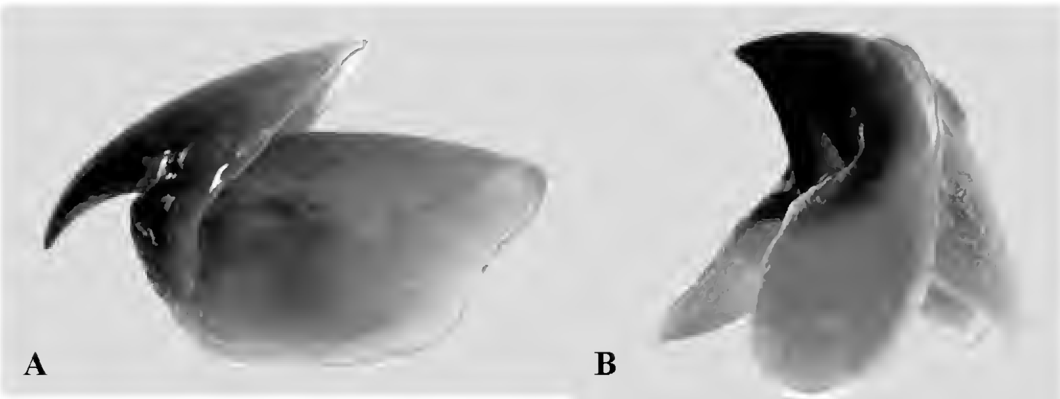


Fig. 52. *Todarodes filippovae*: (A-C) MV F89691; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

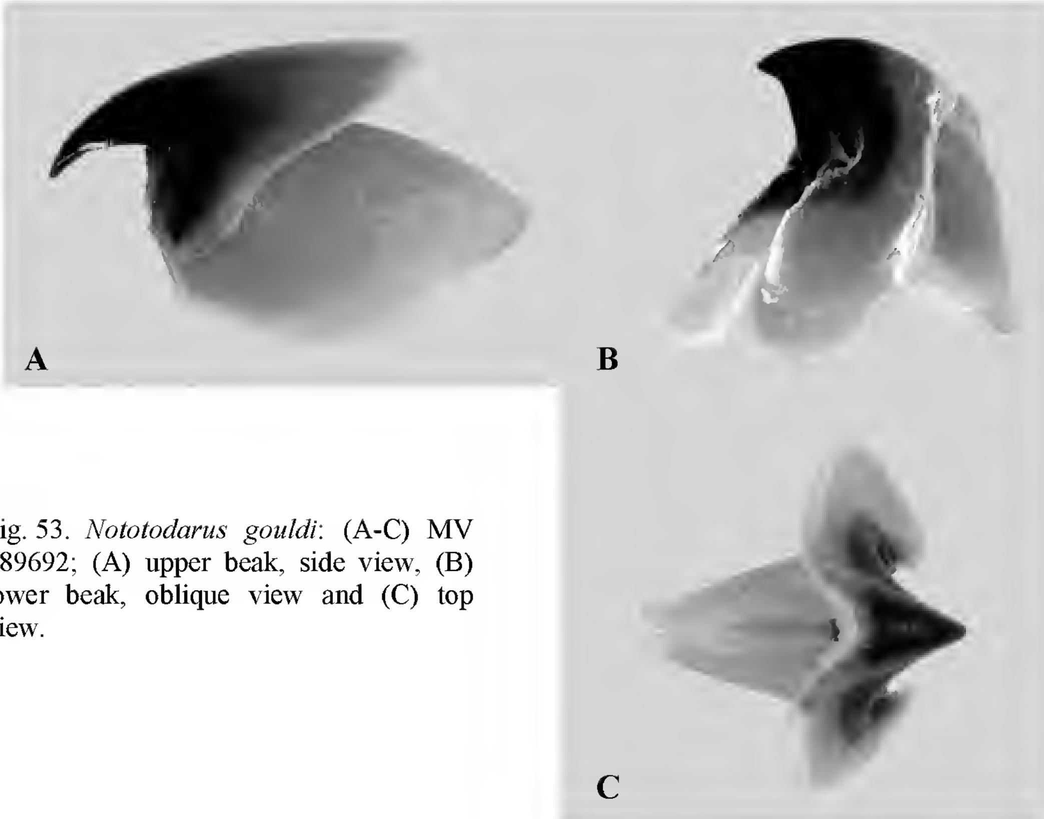


Fig. 53. *Nototodarus gouldi*: (A-C) MV F89692; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

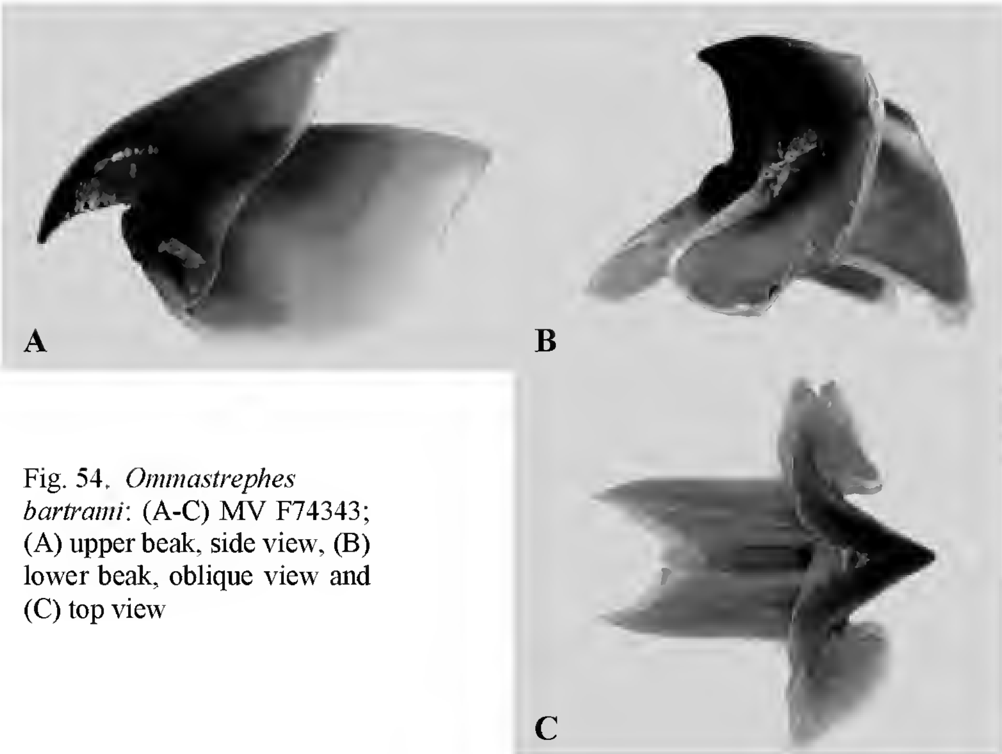
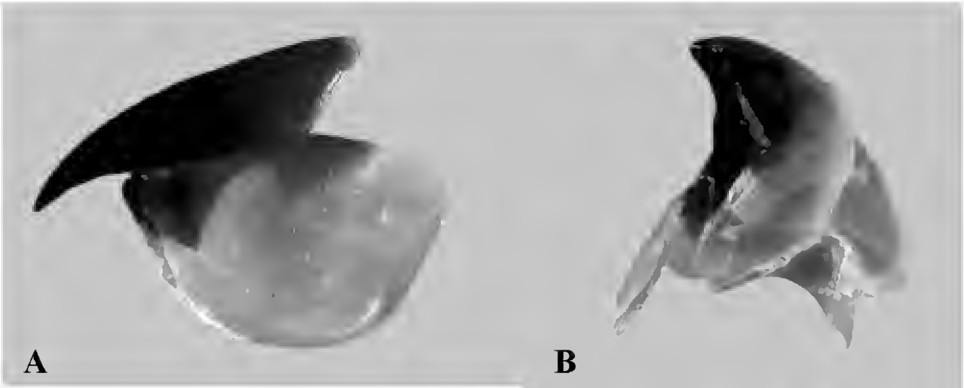


Fig. 54. *Ommastrephes bartrami*: (A-C) MV F74343; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view



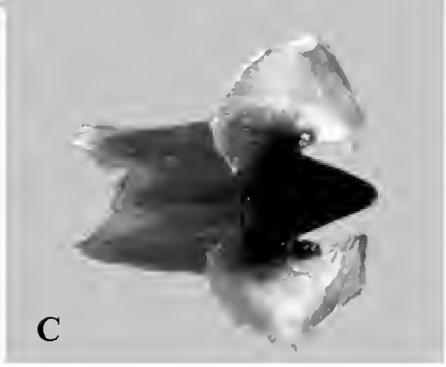


Fig. 55. *Eucleoteuthis luminosa*: (A-C) MV; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

Fig. 56. *Ornithoteuthis volatilis*: (A-C) MV F51652; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

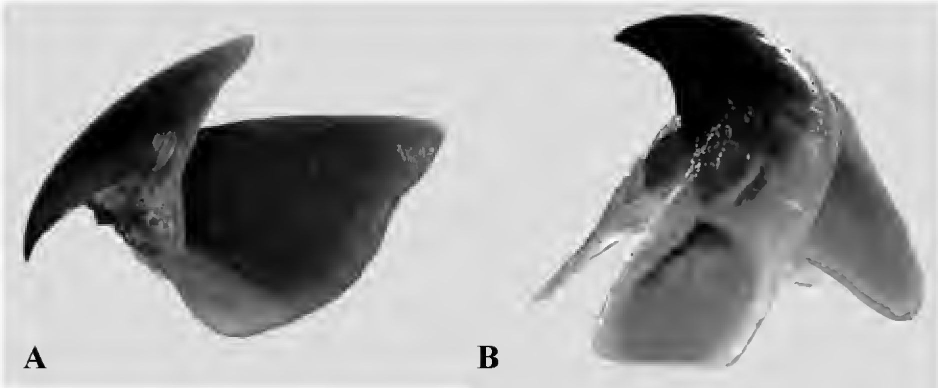
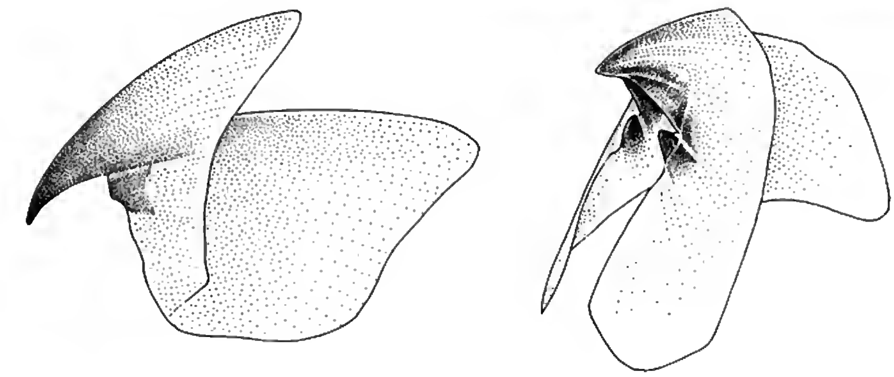
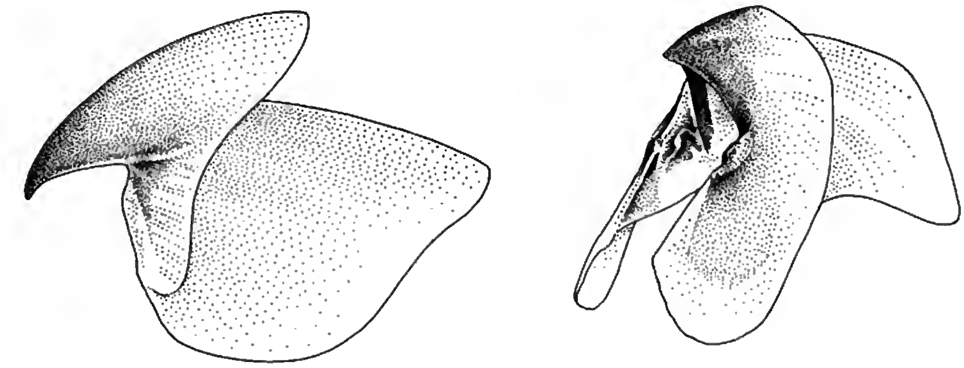


Fig. 57. *Mastigoteuthis cordiformis*: (A-C) MV F89687; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.



A B

Fig. 58. *Cranchia scabra*: (A, B) MV; (A) upper beak, side view, (B) lower beak, oblique view.



A B

Fig. 59. *Liocranchia reinhardti*: (A, B) MV F65937; (A) upper beak, side view, (B) lower beak, oblique view.

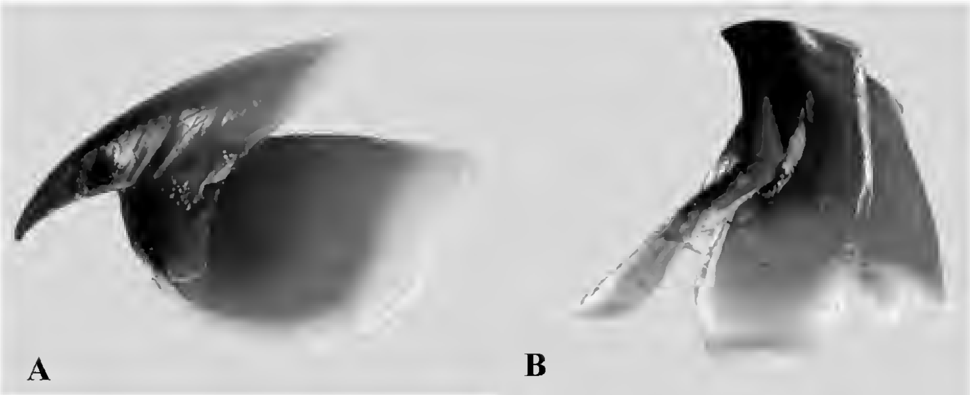


Fig. 60. *Megalocranchia abyssicola*: (A-C) MV F80436; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

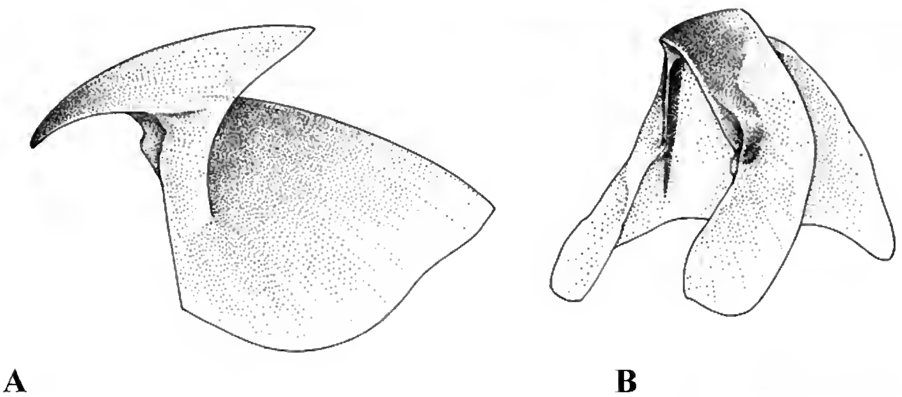


Fig. 61. *Sandalops melancholicus*: (A, B) MV F78244; (A) upper beak, side view, (B) lower beak, oblique view.

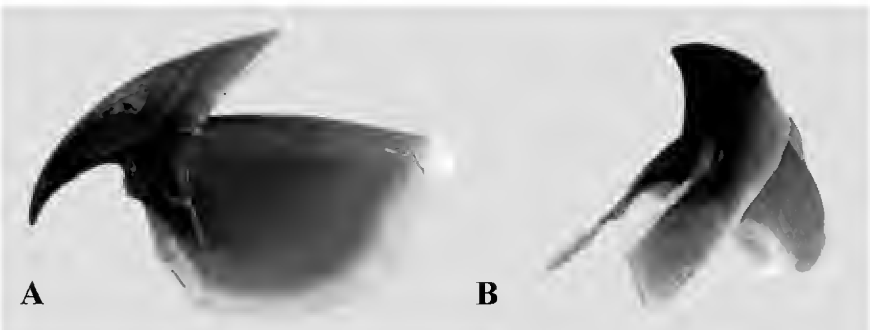


Fig. 62. *Teuthowenia pellucida*: (A-C) MV F78349; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

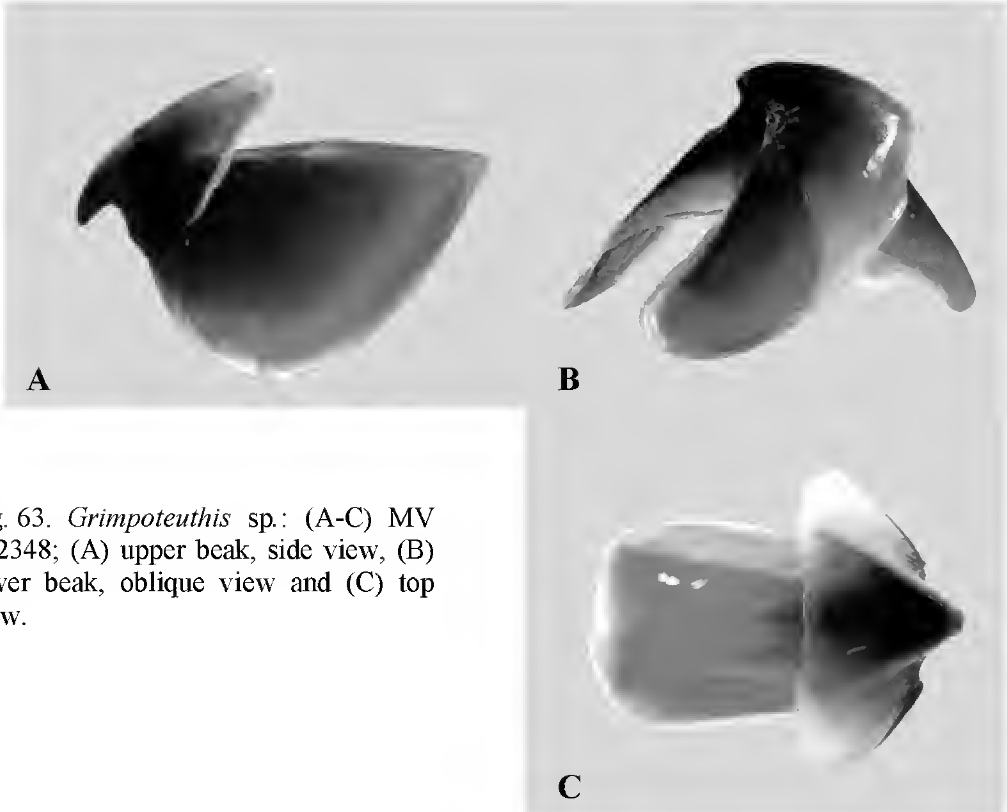


Fig. 63. *Grimpoteuthis* sp.: (A-C) MV F52348; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

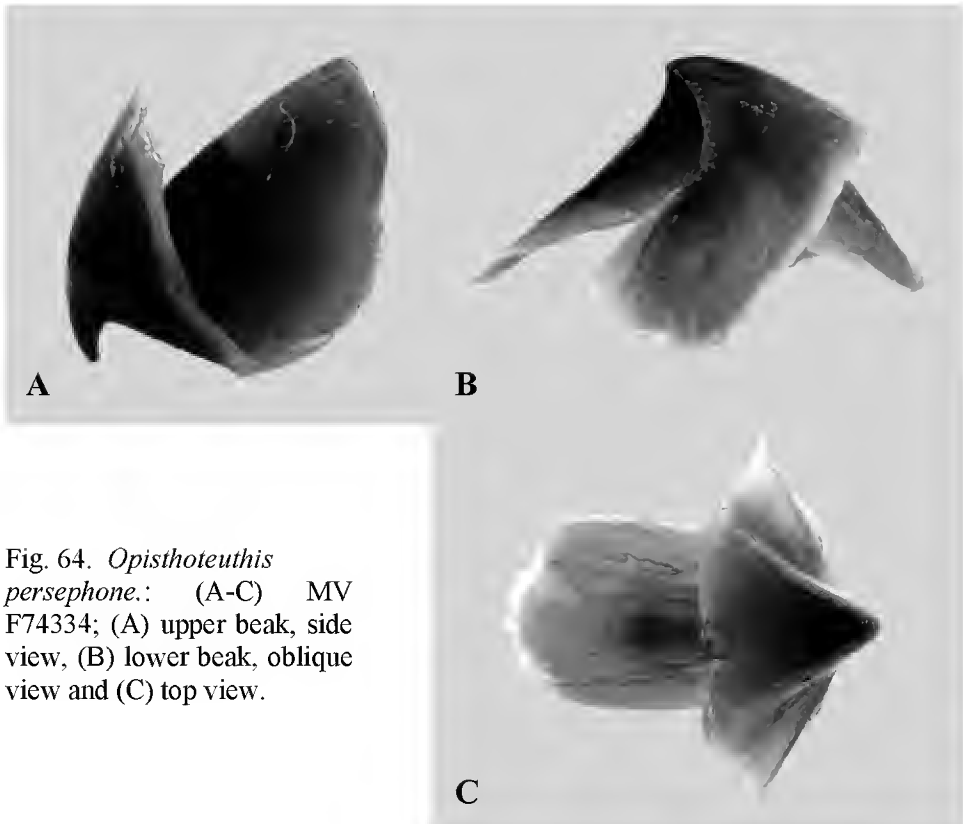


Fig. 64. *Opisthoteuthis persephone.*: (A-C) MV F74334; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

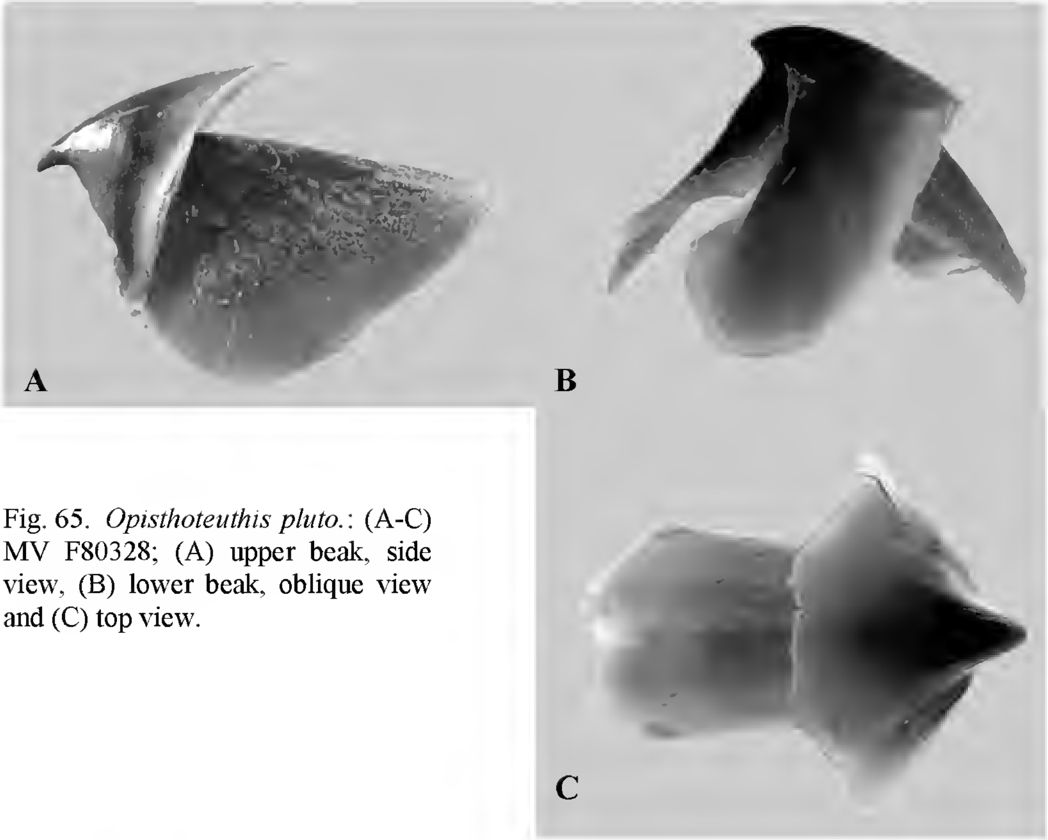


Fig. 65. *Opisthoteuthis pluto.*: (A-C) MV F80328; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

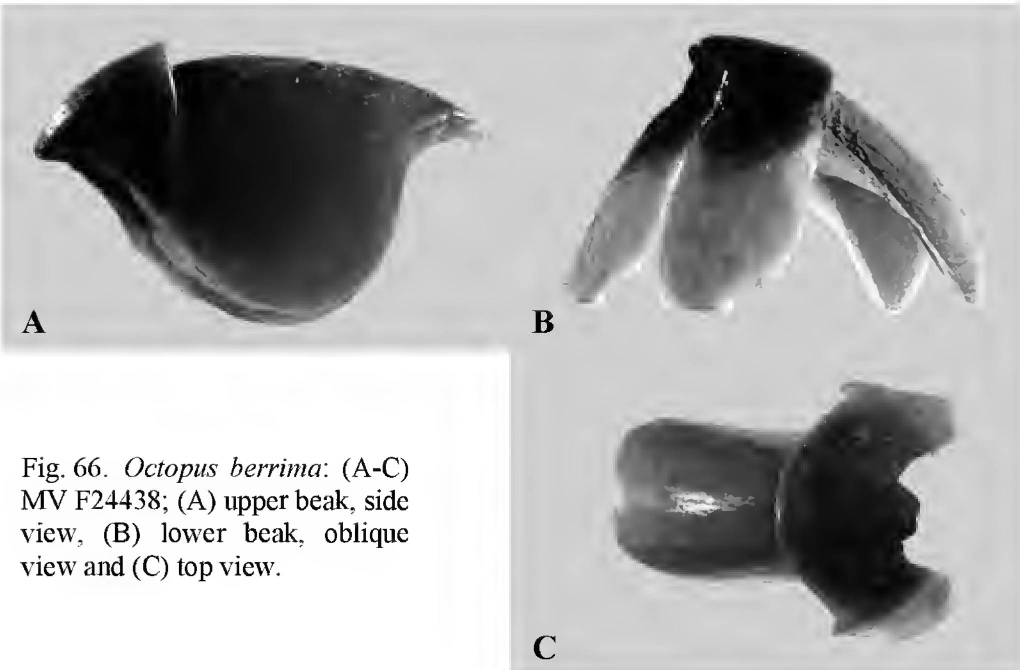
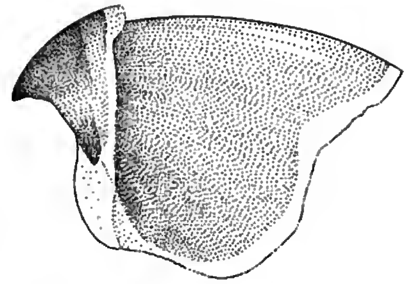


Fig. 66. *Octopus berrima*: (A-C) MV F24438; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.



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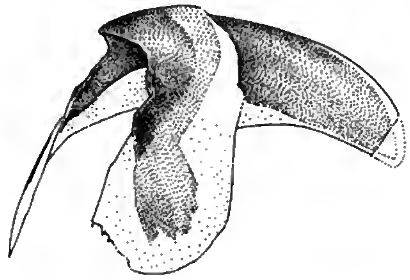

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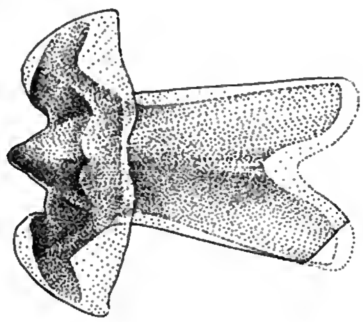
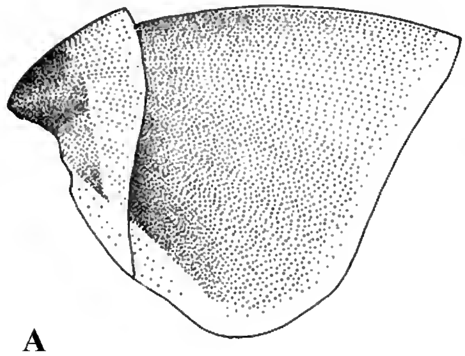


C

Fig. 67 *Octopus bunurong*: (A-C) MV F1516; (A) upper beak, side view, , (B) lower beak, oblique view and (C) top view.



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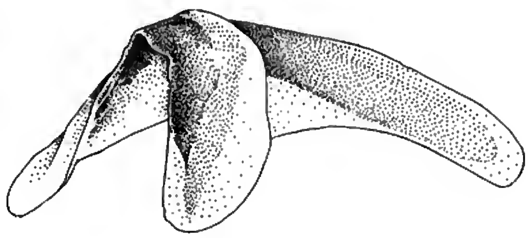

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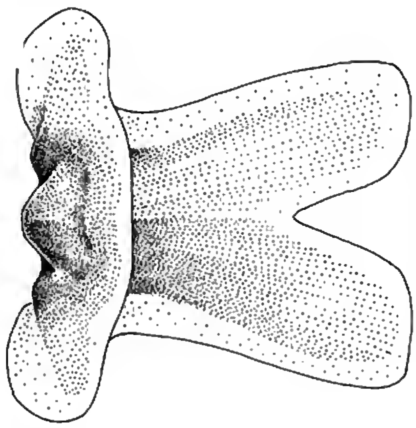


C

Fig. 68. *Octopus kaurna*: (A-C) MV F24495; (A) upper beak, side view, , (B) lower beak, oblique view and (C) top view.

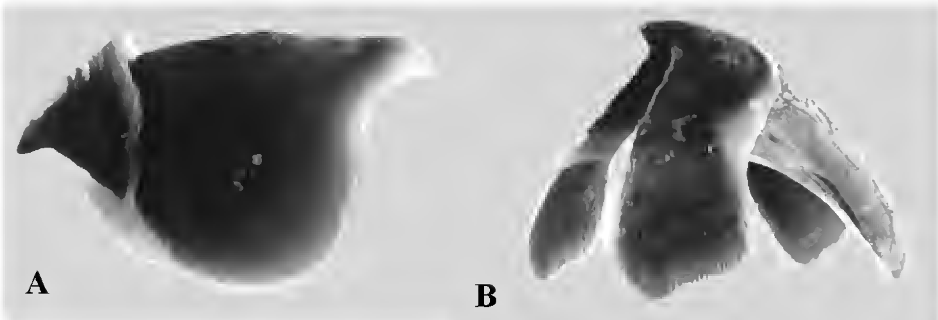


Fig. 69. *Octopus maorum*: (A-C) MV F85767; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

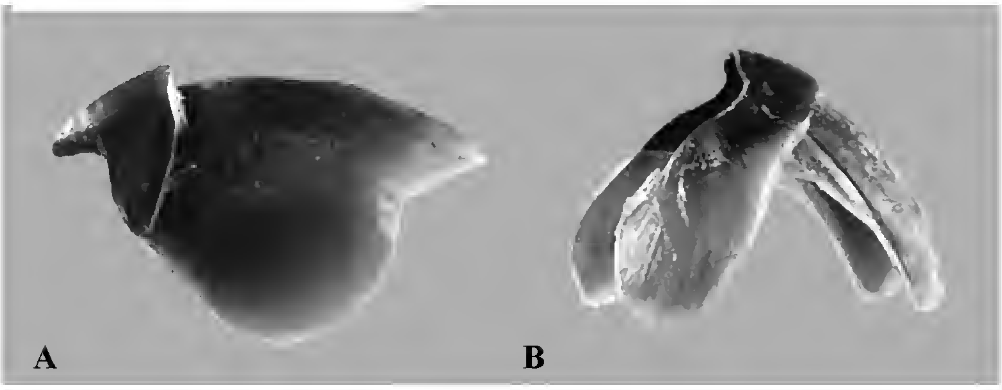
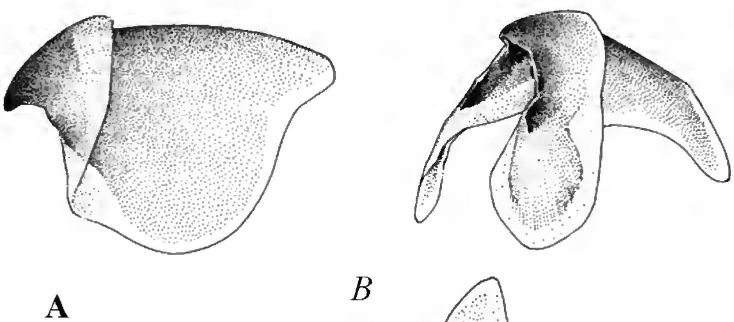


Fig. 70. *Octopus pallidus*: (A-C) MV; (A) upper beak, side view, (B) lower beak, oblique view.



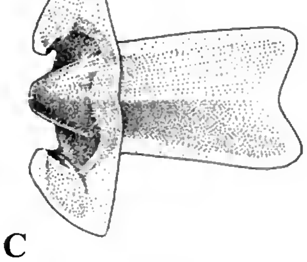
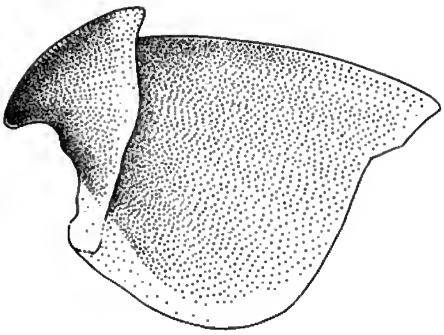


Fig 71. *Octopus superciliosus*: (A-C) MV F51371; (A) upper beak, side view, , (B) lower beak, oblique view and (C) top view.



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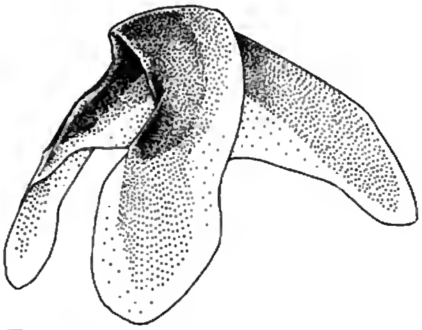
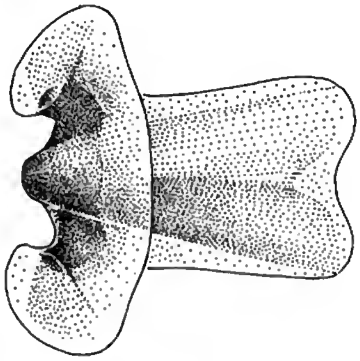
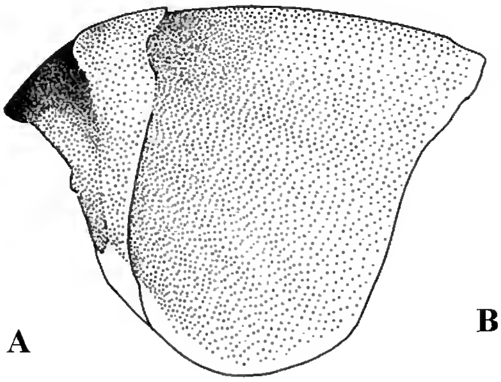


B

Fig. 72. *Octopus warringa*: (A-C) MV F77870; (A) upper beak, side view, , (B) lower beak, oblique view and (C) top view.



C



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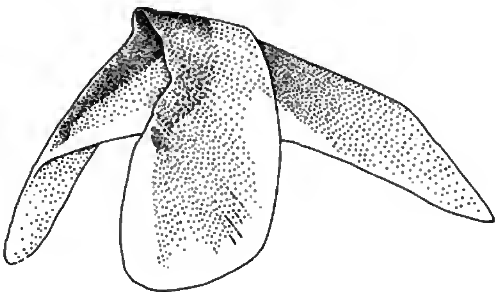
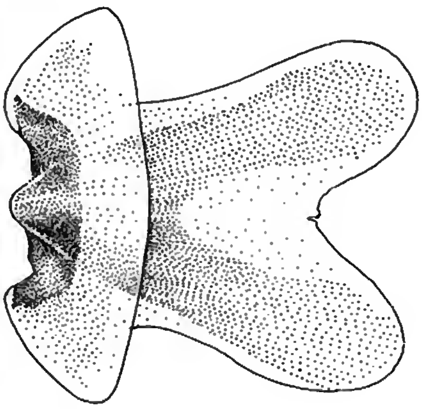


B

Fig. 73. *Hapalochlaena maculosa*: (A-C) MV F24458; (A) upper beak, side view, , (B) lower beak, oblique view and (C) top view.



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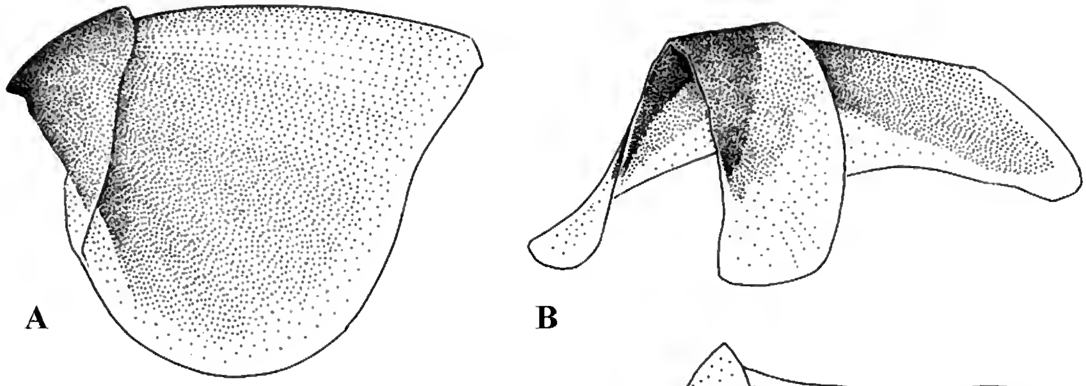

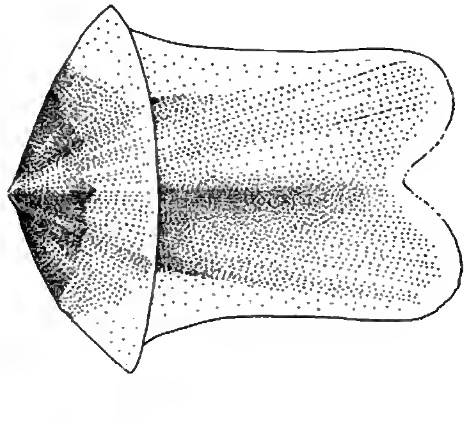

Fig. 74. *Eledone palari*: (A-C) MV F65971; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

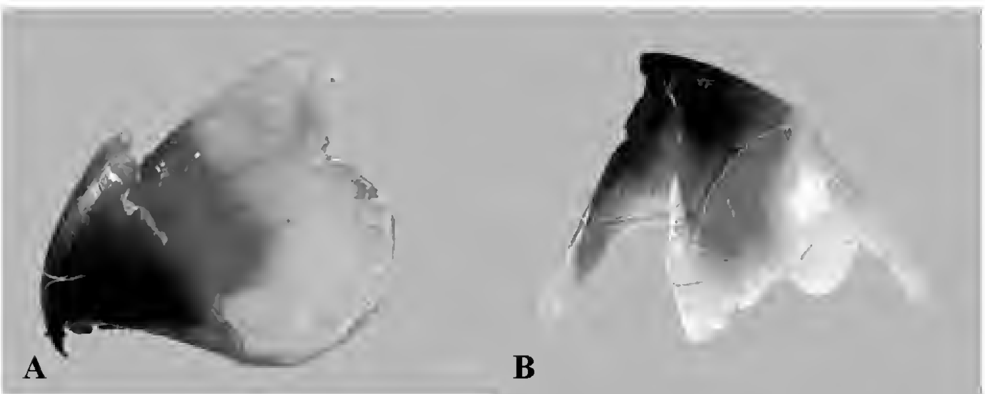

Fig. 75 Ocythoe turberculata: (A-C) MV F82725; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

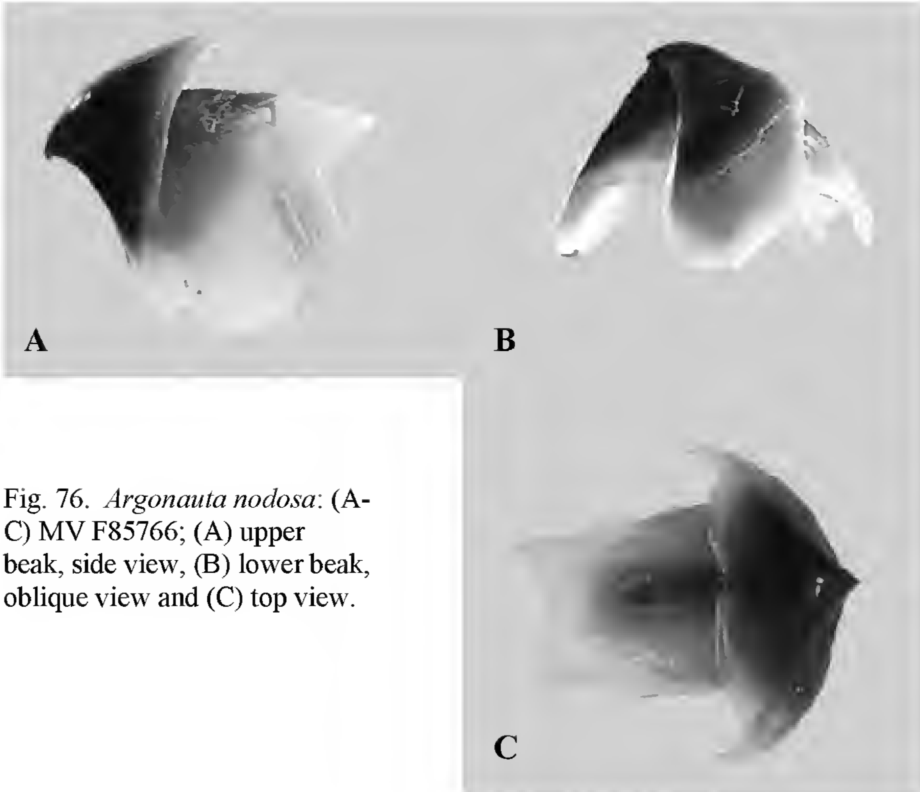

Fig. 76. *Argonauta nodosa*: (A-C) MV F85766; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.

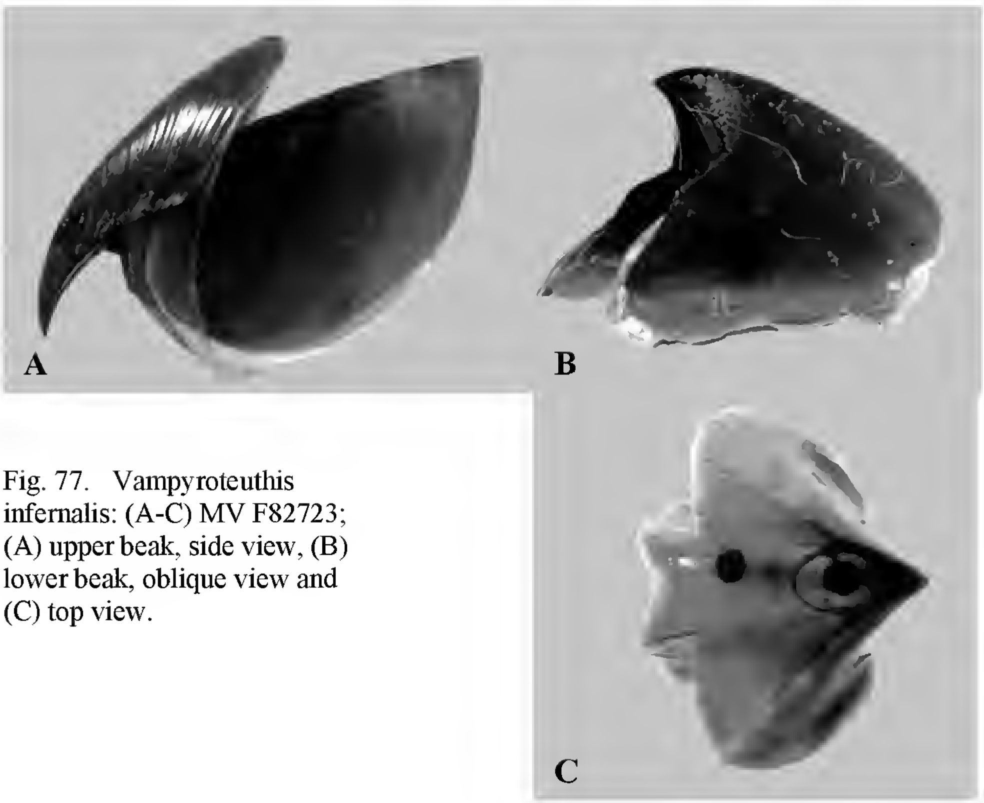

Fig. 77. Vampyroteuthis infernalis: (A-C) MV F82723; (A) upper beak, side view, (B) lower beak, oblique view and (C) top view.